Horticulture

FRUIT PRODUCTION

TEXTBOOK FOR CLASS XI

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FOREWORD

Pandit Sunderlal Sharma Central Institute of Vocational Education (PSSCIVE) has taken up an important and innovative project of the development of curricula and instructional materials for vocational courses on the advice of the Joint Council of Vocational Education. It proposes to develop/revise competency-based curricula and bring out textbooks, practical manuals, audio and video materials, etc. for every course in existence or proposed to be introduced in the higher secondary vocational education system.

The present title shows the commendable work done by the Institute in meeting the requirement of instructional materials for student and teachers. Developed through a comprehensive mechanism, the title is the product of significant contributions made by several experts and others. This has been duly acknowledged in this book elsewhere. All communications and observations on this project should be sent to the Joint Director, PSSCIVE, Bhopal.

A.K. SHARMA
Director
National Council of Educational
Research and Training

New Delhi
April 1999

THE CONSTITUTION OF INDIA

PREAMBLE

WE, THE PEOPLE OF INDIA, having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens:

JUSTICE, social, economic and political;

LIBERTY of thought, expression, belief, faith and worship;

EQUALITY of status and of opportunity;
and to promote among them all

FRATERNITY assuring the dignity of the individual and the unity and integrity of the Nation;

IN OUR CONSTITUENT ASSEMBLY this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

Part IV A
Fundamental Duties

ARTICLE 51A

Fundamental Duties - It shall be the duty of every citizen of India -

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;

(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;

(c) to uphold and protect the sovereignty, unity and integrity of India;

(d) to defend the country and render national service when called upon to do so;

(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;

(f) to value and preserve the rich heritage of our composite culture;

(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;

(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;

(i) to safeguard public property and to abjure violence;

(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement.

PREFACE

The National Policy on Education (1986) envisages that the introduction of a systematic, well planned and rigorously implemented programmes of vocational education is crucial to the proposed reorgansation. In support of this, a variety of programmes/courses have been introduced under the centrally sponsored schemes at the lower secondary, higher secondary and college levels. The programme at the +2 stage has also been finalised.

The paucity of appropriate instructional materials (textbooks and practical manuals) is one of the major constraints in the implementation of the programme and a source of great hardship to the students who opt for vocational courses at the higher secondary stage. To supply these textbooks several efforts have been made in the past by the erstwhile Department of Vocationalisation of Education, NCERT, New Delhi and by the state governments. A review of efforts by the PSSCIVE, Bhopal revealed that there was a large gap between the supply of relevant books for the number of vocational courses and actual requirements.

To fill this gap, the PSSCIVE, Bhopal has taken up a project of developing and publishing a variety of instructional resource materials. The work of this project is being taken up through the mechanism of Working Groups constituted for each course. It includes (i) view of existing curricula and instructional materials (ii) adoption or adaptation of existing books, and (iii) fresh writing of books.

The present book entitled *Fruit Production*, is based on the competency based curriculum developed by the PSSCIVE, Bhopal and fulfils 80 to 90 per cent requirement of any particular state syllabus. The book was earlier developed by a group of experts for the State of Karnataka in a project coordinated by the Educational Consultants India Limited.

I am grateful to all those who contributed to the development and publication of this book in general and the members of the Working Group in particular who reviewed and revised this manuscript. Their names are given elsewhere.

I place on record my appreciation for the untiring efforts put in by Dr A.K. Sacheti as Project Coordinator of the Working Group meeting in planning and organising several such meetings which led to the final form of this title.

I shall be grateful for any suggestions and observations from readers which would help in bringing out a revised and improved version of this title.

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CHAPTER 1

Introduction, Importance, Present Status and Scope of Fruit Production in India

Introduction

Part of the fruit science dealing with the practice of growing fruits is often considered under the title of fruit production. It deals with the act of growing fruits without concerning itself with the names, history, characters, classification, which come under systematic fruit science, or disposal of fruits themselves. Commercial fruit science deals with the marketing and disposal of fruits. Phases of commercial fruit science are preparation of fruits for market, storage and transportation of fruits and other such operations necessary for the delivery of fruits to the consumers.

Therefore in this book efforts have been made to know what fruits are, what is their present status in India, how should we go about their cultivation, what basic principles are involved in their cultivation and what are the basic cultivation practices of important fruit species.

What is a Fruit?

A fruit is normally the developed ovary of a flower, after fertilisation has taken place. Some fruits, however, develop even without fertilisation (parthenocarpically) but do not contain seeds.

In some the fruit is a matured ovary with associated parts while in others it is the simple ovary, while in a few others some floral parts like petals, sepals, stamens, peduncles and receptacles also become part of the fruit pulp. Therefore, from the physiological point of view a fruit may be defined "as the structural entity that results from the development of tissues that support the ovules of a plant". However, a fruit in the horticultural sense is something which can be eaten fresh.

What is Fruit Production?

In general, fruit production has been defined as the cultivation of edible fruits on woody plants.

However, according to Samson (1980) "Fruit production is the cultivation of edible fruits that are consumed either fresh or processed" when cultivation of such crops is done on a large scale and forms part of the farm economy.

Importance of Fruit Production

The importance of fruit growing can be assigned to the following considerations.

1. Fruit as protective food

Fruits are an essential component of a balanced diet being a source of vitamins and minerals and thus rightly referred to as protective food.

The daily requirements of some essential nutrients like proteins, minerals and vitamins can be met if we consume 85 g of fruits per day per head. However, at present the intake is only 60 gms per day per head which is far below the standard. Consequently, ther are a number of diseases which afflict us, as stated below:

2. Medicinal value

Fruits like mango, banana, *bael, jamun,* papaya and *aonla* possess medicinal value. Some fruits are important in treating diseases like scurvy, night blindness, asthma, bronchitis, anaemia, stomach disorders and ulceration. Pectin

S. No	*Nutrients and source*	*Consequences of defincIency*
1.	**Calories and Proteins** Sapota, banana, avocado, date, custard apple and others	Retaraed growth, retarded mental development, irritations, Discolouration of skin and hair, swelling of face and lower body parts.
2.	**Vitamin - A** Cape gooseberry, mango, papaya, persimmon, passion fruit, plum, *phalsa* and others	Inability to see in twilight (Night blindness) sensitivity to bright light, black spots, softening of cornea and eventual blindness.
3.	**Vitamin - B complex** (a) Thiamin (B-1) Cashewnut, walnut, almond, banana, plum, apricot and others	Beri beri and loss of appetite
	(b) Riboflavin (B-2) *Bael, litchi,* papaya, pineapple, pomegrnate and others	Cracks on the corners of mouth, raw red cracked lips, glossy tongue, ulcers in the oral cavity
	(c) Nicotinic acid Cashewnut, date, *bael* and others	Sore tongue and pellagra (showing skin changes in hands, feet, legs, neck).
	(d) Pyridoxin (B)	Ulceration in oral cavity associated with anaemia.
4.	**Vitamin-C** West Indian cherry, *aonla,* guava, citrus, strawberry, pineapple and others	Scurvy, bleeding gums and mucous membranes and susceptibility to common cold.
5.	**Calcium** Lemon, *phalsa,* custard apple, almond and others	Important for formation and growth of bones, teeth and blood clotting
6	**Iron** *Karonda,* guava, grape, date and others	Anaemia, spoon-shaped nails and frequent exhaustion

rich fruits stimulate intestinal activity. Some of the fruits like *bael*, pomegranate and papaya help in stomach troubles. The fruit juices obtained from citrus fruits and pomegranate, coconut water, etc. provide quick energy. The product *triphala*, obtained from *harda*, *bahara* and *aonla* and *chavanparash* from *anola* are well-known Ayurvedic medicines. These qualities are due to their richness in vitamins, minerals and alkaloids.

3. As an economic proposition

A well established and maintained orchard can offer better yields and returns in terms of energy production as compared to field crops in the same piece of land as indicated below:

Crop	*Average yield/ha(t)*	*Calories produced (million cal/ha)*
Wheat	0.85	2.585
Banana	25.00	37.63
Guava	5.50	3.78
Mango	12.50	6.72
Papaya	120 00	47.31

A good grape vineyard can earn a profit of about Rs. 60,000 per hectare. Papain from one hectare of papaya can fetch Rs. 40,000 - 50,000 with an additional Rs. 20,000 from scarred fruit. An *aonla* orchard can give an income of about Rs. 20,000 per hectare. In Karnataka the portion of cultivated area under horticultural crops is 10 per cent but the income is 30 per cent.

4. Employment generation

A fruit grower remains engaged for the whole year and there is an opportunity for maintaining labourers throughout the year, unlike cereals where one cannot be engaged or employ labour during the slack span. For example, the average labour required for fruit production in one hectare works out to 860 man days versus 143 man days for cereal crops. Grape, banana and pineapple generate much larger employment (1,000-2,500 man days) per hectare.

5. Waste-land utilization

Some fruit crops can offer best use of waste-land in arid and semi-arid regions and in addition help in creating an ecological balance. Crops like *her*, *aonla*, custard apple, *phalsa*, wood apple. *karonda*, *lasora*, tamarind and breadfruit can be grown on problematic soils, also this raises the economic standardd of people inhabiting these areas and provides additional food.

6. Home garden crop

Home garden crops can be grown as backyard plants and suppenent family income by cutting down expenses on food. Crops like papaya, lime, lemon, guava, banana, sapota, coconuts, etc. are being grown as hone garden crops.

7. Foreign Exchange earner

Total business in world markets in fruits is about Rs. 25,000 crore against our share of Rs. 200 crore which is less than one per cent. This can be improved by producing more fruits. Since we grow a variety of fruits we can increase our exports and earn more foreign exchange which is essential for the development of the country.

8. Industrial application

Fruit production provides raw material

for the growth of ancillary industries like preservation, dehydration, refrigeration, packaging, transport, wine industry, etc. Similarly sericulture and beekeeping (apiculture) are allied avocations

9. Aesthetic consideration

Fruit trees can add to the aesthetic beauty of the environment and help to reduce pollution. They can be laid out as avenues which may fetch income along with self-satisfaction.

10. Religious significance

Mango, banana and coconut are used in religious ceremonies They are so strongly associated with our culture that there cannot be any religious function without such fruits.

In short, fruit cultivation supplies better food, provides greater calories, develops better resources and yields higher returns per unit area. It also enhances land value and enables better purchasing power for those who are engaged in this industry. Therefore, fruit production is a very important vocation for the health, wealth, hygiene and happiness of any nation

Present Status of the Fruit Industry

India is bestowed with a great variety of climatic and edaphic conditions and therefore, almost any type of fruit can be cultivated in this country It is probably due to these reasons that we are presently foremost in fruit production and with regard to the variety of fruit species that we grow, no other country in the world can compare with India In the northern states of India, temperate and subtropical fruits can be grown successfully while the central and southern states are more favourable for both tropical and subtropical species.

The total area under fruit crops is estimated to be 3.33 million hectares with an annual production of over 28.24 million tonnes (Table 1.1). Among all fruits, mango occupies about 30 per cent area

Table 1.1 : Area and Production of Important Fruits in India

Fruit crop	*Area 000 ha*	*Production 000 t*	*Productivity t/ha*
Mango	1,010	8,504	8 4
Banana	326	6,056	18 6
Citrus	431	3,289	7.6
Apple	187	1,084	5 8
Guava	102	1,015	10 0
Pineapple	55	787	14.3
Grape	25	408	16.3
Sapota	29	410	14.1
Others	1,165	6,687	5 7
Total	3,330	28,240	8 5

followed by citrus and banana at 12 9 and 10.0 per cent respectively Among the different states, Uttar Pradesh has the maximum hectarage followed by Andhra Pradesh, Kerala, Bihar, Maharashtra and Karnataka (Table 1.2). The average production of fruits in the country is one of the lowest (8 5 t/ha) and within the country it varies from 20.2 t/ha in Tamil Nadu to 1 28 t/ha in Goa. This variation itself implies the great need for improvement in production and productivity of fruits. With the present level of production, per capita availability of fruits is far below the recommended level for healthy individuals

Table 1.2 : Area, Production and Productivity of Fruits in India (1989-90)

State/Union Territory	*Area (ha)*	*Production (1)*	*Productivity (t/ha)*
Andhra Pradesh	368504	3872945	10 51
Arunachal Pradesh	17157	39432	2.30
Assam	69124	823396	11.91
Bihar	242491	2475810	10 21
Goa	54394	69850	1.28
Gujarat	73900	934300	12 64
Haryana	28035	290022	10 34
Himachal Pradesh	156469	459990	2 94
Jammu and Kashmir	168358	603500	3.58
Karnataka	190048	2349851	12.36
Kerala	255739	1627888	6.37
Madhya Pradesh	717996	922800	12 85
Maharashtra	220100	1978936	8.99
Manipur	18730	127350	6 00
Meghalaya	23280	202928	8.72
Mizoram	7192	34936	4 86
Nagaland	3872	6712	1 73
Orissa	117895	818000	6.94
Punjab	64947	593949	9 15
Rajasthan	19581	62444	3.19
Sikkim	11800	24000	2 03
Tamil Nadu	122670	2466270	20.10
Tripura	41035	324750	7.91
Uttar Pradesh (Hills)	165772	345535	2.08
Uttar Pradesh (Plains)	698142	5662446	8 11
W Bengal	109000	1088790	9.98
Andaman and Nicobar Islands	3507	11479	3 27
Chandigarh	93	184	1 98
Dadar and Nagar Haveli	708	7100	10.03
Delhi	420	5165	12 30
Lakshadweep	300	974	3.25
Pondicherry	623	12135	19 48

Source: Horticultural statistics compiled by National Horticulture Board Ministry of Agriculture, New Delhi 1992 p. 8

Important Features of the Indian Fruit Industry

- Wide variety of fruit species are grown in India ranging from tropical to temperate.
- Fruit production is the highest in the world
- Availability of fruits per capita is much below the required level.
- Productivity is very low (8.5 t/ha)
- Orchards suffer due to inadequate attention and the existence of large numbers of seedling trees

- Regular application of nutrients is almost unknown in crops like mango, guava, ber, aonla, etc.
- Production systems are quite varied from region to region and a large number of varieties are grown to suit various tastes and end uses.
- Post-harvest losses are huge and standardised handling methods are not practised.
- Handling infrastructure is absent.
- Cold storage facilities are very poor.
- Market is unorganised.
- Share in international trade (export) is very poor (1 per cent).
- Some of the chronic problems like mango malformation, citrus decline, mosaic in papaya, bunchy top in banana, unproductivity in grapes, alternate bearing in major fruit crops, etc. are persistent and defying solutions.

However, in the recent past, national debates have emphasised the need for diversification of Indian agriculture from the age old dependence on cereal based cropping systems. This diversification camapign brought to light the potential of horticultural crops including fruit crops in terms of their capability for improving returns per unit area, uplifting the rural economy, earning foreign exchange through exports and generating large employment opportunities in the rural sector. Therefore in the Eighth Plan, the outlay for horticulture has been increased to Rs 1,000 crore and the fruit industry is marching ahead to a better future. Besides our research infrastructure is reasonably good but requires to be geared up for the task ahead.

Scope of Fruit Production in India

Scope for growth of the fruit industry depends on the incentive to farmers to grow fruit crops; adaptability of crops; necessity and availability of inputs; and infrastructure for their distribution, marketing system, industrial support, etc.

India provides ample scope for fruit growing for the following reasons.

(i) The country is bestowed with a great variety of soil and climatic conditions in which a large variety of fruits can be cultivated, thus providing tremendous scope for the growth of this industry. The country has temperate, subtropical and tropical climates and for each climate type, fruit crops are grown like:

Temperate—Apple, pear, peach, plum, cherry, walnut, almond, apricot, strawberry.

Subtropical—Citrus sp, litchi, loquat, guava, grapes, pomegranate, *ber*, *aonla*, persimmon *phalsa*,

Tropical—Mango, banana, papaya, sapota, avocado, jackfruit, pineapple, custard apple.

There are crops which can grow both under subtropical and tropical conditions like mango, grapes, pomegranate, guava, *ber*, fig. Similarly, there are crops suited to arid conditions like *ber*, *karonda*, *aonla*, custard apple, date; for wet conditions like banana, mandarins, pineapple, jackfruit, mangosteen, etc. Likewise, there are crops for saline and poor soils. Thus adaptability is no limitation.

(ii) Since the country is basically cereal producing, therefore, we must emphasise more on the cultivation of

fruits which are rich in vitamins and minerals essential for healthy growth of the body. As our large population provides a sufficient market even for the provision of the bare minimum of 85 g per head per day, therefore, fruits must be grown as a necessity to meet the daily food requirement for 900 million people

(iii) No good or flat land is available for increasing the area under fruit crops owing to its greater use for cereal crops, establishing industries and habitation, we have to make use of uplands which are only suitable for tree crops which can provide food. So fruit crops have a great future. Similarly, problematic soils like saline and alkaline, which cannot be put under cereal cultivation owing to greater sensitivity, can be successfully used for fruit crops like *ber*, date, pompegranate and even their tolerance can be enhanced by using resistant rootstocks. Available waste-land can be advantagenously used for protecting the environment and providing food, fodder and fruits

(iv) Present position of fruit crops by area and productivity has been presented in Table 1.1.

The total area under fruits represents only 2 5 per cent of the total cropped area in the country. Of the 28.2 million tonnes of fruits produced, about 25-30 per cent are lost due to improper harvesting and other post-harvest losses due to poor handling, packing, transport and storage. Thus actual availability of fruits in the country is only 20.15 million tonnes annually, whereas the actual need for 900 mmillion people at the rate of 85 g per day per head is 28.0 million tonnes per annum. Our target at the end of the Seventh Five Year Plan was to cover 2.9 million hectares area and achieve 25 million tonnes fruit production and at the end of Eighth Plan, it would be to cover 4.00 million hectares and obtain 40 million tonnes production. Therefore, there is a yawning gap between the demand and supply For example, our average consumption is only 65g per day per person against 85 g being the minimum dietary requirement. Therefore, it provides ample scope for increasing the area under fruit production to four million hectares by A D. 2000.

(v) At present, our share in terms of export of fruits in the international trade is insignificant. Since 1979-80 our exports of fresh and processed fruits has declined from Rs 17 crore to Rs 14 crore and then it rose to 24 in 1988-89 and now it is around Rs 350 crore per annum (1993-94). Of this, mango accounts for the bulk of our exports trade in fruits Among the other fruits exported are banana, citrus, grapes apple, walnut, pomegranate, sapota, tamarind, and processed pineapple Our production of banana, citrus and apple is considerable, but the share in the international trade is negligible. There exists a tremendous scope for the export of these crops especially to the oil rich Middle East countries which have become the biggest consumers of fruits Therefore beaides being important commercially, their cultivation provides tremendous scope and possibility of growing many fruit species and exporting them.

(vi) In recent years our communications and transport systems have grown rapidly The processing industries are also coming up, which will provide support to the growth of this industry. Therefore there is a great scope to grow fruit crops:

— to exploit the great variety of climate, soil, uplands, etc.

— to meet the requirement of fresh fruits in relation to population growth based on nutritional needs.

— to meet the requirement of the processing industry,

— to substitute import of fruits on which large amount of foreign exchange is being of spent,

— to increase and develop fruit production with a view to achieve sizeable exports.

— to improve the economic condition of the farmers and to engage more farm labour to overcome unemployment, and to protect the environment.

Fruit plants are multipurpose in nature and therefore more emphasis should be given on their plantation.

QUESTIONS

1. What is meant by a 'fruit'? Discuss its economic importance.
2. 'Fruits are a protective food' Justify the statement based on the nutritive value of fruits
3 Write a note on the present status and future prospects of fruit production in India

CHAPTER 2

Classification of Fruit Crops and Fruit Growing Zones in India

Introduction

For the convenience of study and handling, fruits can be classified on a different basis such as natural growth, climate, cotyledons, family, botanical constituent and ripening pattern.

Classification of Fruits

Classification based on natural growth

1. Woody trees: Woody trees are of two types—

(i) **Tree fruits**
Fruits which are borne on trees are referred to as tree fruits. They are tall such as mango, guava, citrus, avocado.

(ii) **Small fruits**
Fruits borne on bushes or vines are referred to as small fruits such as grape, black-berry, blueberry, gooseberry, cranberry, *phalsa*, etc.

2. Herbacoeous plants

The fruits which are borne on perennial herbaceous plants banana, strawberry, pineapple fall under this category.

Classification based on climatic requirements

1. Tropical fruits
Trophical fruits are evergreen trees sensitive to low temperatures. They do not show dormancy. Banana, mango, pineapple, papaya, jackfruit, sapota, cashew, custard-apple are typical examples of tropical fruits

2. Sutropical fruits
Subtropical trees are both evergreen as well as deciduous and are able to tolerate frost to a certain extent. For better fruiting they require a period of low temperatures. Examples of the fruits under this group are pomegranate, litchi, loquat, *aonla*, *phalsa*, *ber*, and citrus species.

3. Temperate fruits
Temperate fruits are deciduous trees and require chilling for breaking dormancy which is induced because of shorter day conditions. They lose their leaves in autumn and remain dormant during winter and can tolerate cold and frost. The apple, pear, peach, plum,

almond, apricot, cherry, pecan, walnut, strawberry and raspberry are typical examples of temperate fruits

Classification based on number of cotyledons

1. **Monocotyledonous fruits** Monocotyledonous fruits are banana, pineapple, date

2. **Dicotyledonous fruits** Dicotyledonous fruits are papaya, mango, guava, sweet orange, mandarin, lime, lemon, apple, pear and peach

Classification based on family

1 **Anacardiaceae**	Mango, cahsew, pistachio
2 **Annonaceae**	Custard apple, soursop
3. **Apocynaceae**	*karonda* and nettle plum
4. **Bromiliaceae**	Pineapple
5. **Euphorbiaceae**	*Aonla*
6. **Ebnaceae**	Persimmon
7. **Caricaeae**	Papaya
8. **Fagaceae**	Chestnut
9. **Lauraceae**	Walnut and pecan nut
10. **Lauraceae**	Avocado
11. **Moraceae**	Jackfruit, fig and mulberry
12. **Myrtaceae**	Guava, *jamun*
13. **Nusaceae**	Banana
14. **Oxalidaceae**	Averrhoa *(Kamrakh)*
15 **Palmaceae**	Date
16. **Psssifloraceae**	Passion fruit
17. **Punicaceae**	Pomegranate
18 **Rhamnaceae**	*Ber*
19. **Rosaceae**	Apple, pear, peach, plum. almond, apricot, cherry, loquat, strawberry
20. **Rutaceae**	Sweet orange, mandarin, lemon, lime, grapefruit, *bael,* woodapple.
21. **Sapindaceae**	Litchi
22 **Sapotaceae**	Sapota
23. **Solanaceae**	Gooseberry
24. **Tiliaceae**	*Phalsa*
25. **Vitaceae**	Grape

Classification based on botanical part

Under this classification, there are three categories of fruits. 1 Simple 2. Aggregate, and 3 Multiple

1 **Simple fruits**

A fruit developed from the ovary of a flower with or without accessory parts is referred to as simple fruit They are of two types.

(i) **Fleshy fruits** : Fleshy fruits refer to the kind of fruits in which the complete pericarp or major part of it is pulpy and juicy The pericarp is further divided into three parts· epicarp, (outer), mesocarp (middle) and endocarp innermost). The type of endocarp, however, varies from species to species.

It can be membranous, pulpy or hard. Fleshy fruits are again divided into four groups:

a. *Berry·* Fruits are formed from monocarpellary or polycarpellary syncai pous ovary and the ovary is mostly superior but sometimes can be inferior. However, the pericarp is juicy and pulpy and the endocarp is absent or membranous. The examples of this kind of fruits are grape, guava, date, avocado, passion fruit, papaya, banana, *jamun,* etc.

b. *Hesperidium.* Hesperidium is a specialised berry formed from superior many celled syncarpous ovaries with axil placentation. The salient feature of this fruit is that the endocarp projecting inward form separate chambers and the epicarp and mesocarp fuse together to form the rind of the fruit, e.g. sweet orange, mandarin and other citrus fruits.

c. *Drupe:* Drupe is a mostly fleshy and single seeded fruit with its pericarp differentiated into epicarp, mesocarp and endocarp. The endocarp is stony, therefore, referred to as stone fruit e.g. mango, *ber*, peach, plum, cherry, etc.

d. *Pome.* Pome is a pulpy fruit developing from two or more celled syncarpous ovaryies and surrounded by fleshy thalamus e.g. apple, pear, loquat, etc.

(ii) **Dry fruits:** In dry fruits, the pericarp is dry and hard. They are of two types:

a. *Deshicent fruit:* On maturity these fruits open from certain points or lines and they contain many seeds. They are not important from a botanical point of view.

b. *Indehiscent:* Indehiscent fruits on maturity do not open. They contain only one or two seeds. Nuts and important fruits in this catgegory are cashew nut, pecan nut, chestnut, almond.

2. **Aggregate fruits**

This group refers to the fruits which develop from a single flower with apocarpous pistil. Each unit of this aggregate fruit is called a fruitlet. They are four types:

(i) *An etario of follicles.* Fruit formed by an aggregate of follicles, e g., *michelia champaka.*

(ii) *An etario of achenes:* Fruits which are an aggregate of achenes e.g strawberry.

(iii) *An etario of drupes.* An aggregate of drupes e g. blackberry and raspberry.

(iv) *An etario of berries:* Fruit conprising an aggregate of berries e.g. custard-apple.

3. **Multiple fruits**

These fruits develop from a whole inflorescence rather than an individual flower. They are of two types·

(i) *Sorosis:* Sorosis is a multiple fruit developing from a spike or spadix In this case the flowers fuse together by their succulent sepals and the axis bearing them grows and becomes fleshy and thus the whole inflorescence forms a compact mass to be used as fruit e.g. mulberry, jackfruit and pineapple.

(ii) *Syconium:* The fruit develops fron hypanthium inflorescence. In this case the receptacle is hollow and cup-shaped and contains both male and female flowers. This receptacle becomes fleshy and juicy and is used as a fruit e.g. fig.

Classification based on edible portion

1. **Flesh thalamus** apple and pear
2. **Pericarp and thalamus** guava
3. **Pericarp** date, custard apple and raspberry.
4. **Pericarp and placenta** grape
5. **Mesocarp** mango, papaya and sapota
6. **Mesocarp and epicarp** *ber, aonla,*

peach,plum
7. **Mesocarp and endocarp** banana and *bael*
8. **Fleshy aril** litchi
9. **Juicy aril** pomegranate
10. **Receptiacle** fig and strawberry
11. **Bracts and parianth** pineapple
12. **Bracts, parianth and seeds** jackfruit
13. **Peduncle and cotyledon** cashew
14. **Juicy placental hair** mandarin and orange
15. **Enddosperm** coconut

Classification based on ripening pattern

1 **Climacteric**
Fruits which are harvested mature but could be ripened artificially e.g mango, sapota, banana, papaya, avocado, apple, pear, peach and plum.

2. **Non-climacteric**
Fruits which are harvested ripe an cannot be ripened artificially e.g. organge, mandarin, lime, grapefruit, grape, pineapple, strawberry and *jamun*.

Fruit Growing Zones in India

India is bestowed with a variety of soils andd climates and therefore, provides great scope for growing a wide variety of fruit species and has the ability to make available a variety of fruits throughout the year both for internal consumption and the export market.

From the horticultural point of view the country can be divided into the following six agro climatic zones.

1. **Temperate zone**
Jammu and Kashmir, Himachal Pradesh and parts of Uttar Pradesh, Arunachal Pradesh and a part of Nagaland.

2. Northest Subtropical
Rajasthan, Punjab, Haryana, a part of Uttar Pradesh and a part of Madhya Pradesh

3. **Northeast Subtropical**
Bihar, Assam Meghalaya, Tripura, part of Arunachal Pradesh and a part of West Bengal.

4. **Central Tropical**
Part of Madhya Pradesh, a part of Maharashtra, Gujarat, parts of Orissa, a part of West Bengal, parts of Andhra Pradesh and parts of Karnataka

5. **Southern Tropical**
Karnakata, parts of Andhra Pradesh, parts of Tamil Nadu and parts of Kerala.

6. **Coastal Tropical humid**
Parts of Maharashtra, Kerala, parts of Karnataka, parts of Andhra Pradesh, parts of Tamil Nadu, parts of Orissa, parts of West Bengal, parts of Tripura and Mizoram.

QUESTIONS

1 Enumerate the different types of classifications followed to classify fruit crops Describe the classification of fruits based on climatic requirements.

2 Explain the following.
   i) Aggregate fruits
   ii) Climacteric fruits
   iii) Small fruits

3. List the fruit zones of India. Indicate the zone in which your area falls and the fruit crops that can be grown there?

CHAPTER 3

Selection of Site and Planning of an Orchard

Introduction

Orcharding is a long-term venture of growing perennial fruit plants. Therefore, preparation of a plan in advance is absolutely essential, since any mistake made in the beginning regarding the establishment of an orchard may result in heavy losses, and it may be too late to correct it later, hence, it is advisable to seek professional guidance to prepare a fool proof plan to ensure the most economic orchard management. In addition to layout, proper location of roads, drains, irrigation, channels, fence and wind-breaks is also necessary.

Selection of Location and Site

A proper site, having all the requirements for good plant growth, must be selected. A few factors that one has to consider other than soil and climate, are as follows:

(i) The site should be located in the vicinity of the market. As most fruits are perishable in nature, quick transport to the consumers' market will minimise losses. So, if the market-place is nearby and well connected by suitable means of communications, the transport cost can also be reduced.

(ii) It should be in the vicinity of a perennial water source.
Securing supply of perennial irrigation for satisfactory growth of plants, and for spraying at reasonable costs is possible only if there is a source of plentiful water nearby.

(iii) Availability of cheap labour in the vicinity will also reduce the production cost.

(iv) It is safer to select a site close to a successful established orchard. One can benefit from the experience of a successful orchardist.

(v) The grower should reside in or near this orchard for effective supervision Therefore, availability of medical, education and social amenities in the vicinity should also be considered while selecting the site

After selecting a suitable location and site, it is essential to prepare a tentative plan for the orchard, showing

the fruits to be grown in the different blocks, and other permanent infrastructures

Planning of an Orchard

A prospective fruit grower must know the fruit crops and varities suitable for the region for successful fruit growing. The orchard should be well planned to make it aesthetically pleasing.

As every site has its own peculirities, a standardised plan cannot be suggested to suit every situation. However, the following points may be considered as guidelines, though all of them may not be relevant for all situations.

- The orchard shouldd present a beautiful view from the main entrance.
- The orchard should be established in the right location having suitable climatic and soil conditions and other physical facilities, such as a dependable water source required for successful fruit growing.
- Evergreen fruit plants should be planted in the front, and deciduous plants at the rear.
- The shorter fruit trees may be assigned space in the foreground and the taller ones occupy the rear part of the orchard to facilitate watch and ward
- Buildings, such as the owner's residence, sheds and labourers quarters, should be located near the road and at the centre of the orchard. The area designated for construction should be left unplanted, if the construction is likely to be delayed.
- Roads should be straight and at right angles to each other, occupying the minimum space but ensuring easy movement of vehicles and machinery. The roads should be given a slope to drain water.
- A well should be dug much ahead of planting as the trees have to be watered immediately after planting For easy distribution of water at low cost, the well should preferably be located at the highest point.
- The drainage and irrigation channels should be kept concealed as much as possible from visitors, and laid out in such a way as to irrigate all the plots or areas efficiently and economically.
- Fruit trees requiring frequent irrigation should be close to the source of water, while rain fed crops may be kept further away.
- Fruit varities ripening at the same time should be located in adjoining plots to facilitate proper orchard operations and watch and ward.
- Fertile areas of the orchard should be planted with more paying and heavy feeding fruit trees.
- Fruits that attract birds and other animal pests are prone to be damaged by them. Hence, they shouldd be located close to the watchman's shed
- The spacing of fruit trees for each species should be optimum.
- The system of planting of fruit crops to be addopted in a particular plot should be decided upon before laying out the orchard.
- Non-self-propagating fruit trees requiring pollenisers should be planted mixed or polliniser varities be side grafted on the fruit trees propagating themselves to ensure optimum fruit set.

- Provision should be made for windbreaks around the orchard to protect the trees from the ravages of strong wind.
- Fencing of the orchard should be done sufficiently ahead of planting.
- Under dryland or rain fed conditions *in situ* method of planting or rootstocks should be followed, and the desirable scion variety side-grafted later when the rootstocks attain optimum size.
- Selection of fruit varieties should be suitable for the area and procurement of genuine plant material should be from reliable sources.

Preliminary Operations

After selecting a suitable site, the first step should be to prepare the ground well in advance of planting by removing all vegetation, including shrubs and standing trees. If the land is undulating, levelling may involve considerable shifting of soil, in which case the site may be divided into two or more sections, and levelled sectionwise. In sloping or hilly terrain, the land should be divided into terraces depending upon the topography of the land, and the levelling done within the terraces. This will prevent soil erosion. A green manure crop should be grown and ploughed into the soil to improve its physical and chemical condition

Climate

The climate of the site where fruit crops are to be grown on a commercial scale must be considered critically. Factors like temperature (day and night), rainfall (amount, intensity and frequency), wind (direction and velocity), light (intensity and duration), atmospheric humidity, occurrence of hailstorm and frost are very important for selection of fruit crops to be grown in a particular region. The following are the important crops suited to different climate regions:

Tropical climate

Mango, banana, citrus, papaya, pineapple, jackfruit, sapota, *ber* and cashew.

Subtropical climate

Mango guava, grape, litchi, citrus, *phalsa*, almond and walnut.

Temperate climate

Apple, peach, plum, pear, apricot, cherry, persimmon, strawberry.

While planning an orchard, the fruits suitable to the particular locality should be kept in mind and planting of fruit crops done accordingly while taking into consideration the topography and other factors.

Soil

Though most of the fruits may be grown on a wide variety of soils, a loam or sandy loam soil is considered to be ideal for most fruit crops. The orchard site should have at least 1.0 to 1.25 metres deep soil for the fruit trees to spread their roots and grow. A sandy soil is suitable for growing cashews; gravelly red laterite soil for mango, jackfruit and cashew; and loamy soil for banana, citrus, papaya, sapota, litchi, etc.

Planning of Fence and Hedges

To prevent damage to trees, destruction from stray and wild animals, and pilfering of fruits and other orchard property by trespassers, a fencing should be erected on all sides of the orchard well in advance

Fences made by using dead thorny bushes require fequent repair and replacement Barbed wire fencing is preferred though the initial cost is high A brick wall topped with glass pieces is permanent and very effective, but it is very expensive Thus, the best choice is the barbed wire fence, which can be further strengthened by raising live hedges, alongside to form a thick impenetrable live wall around the orchard for privacy and complete protection.

An ideal live hedge must have the following desirable attributes,

— It should be quick growing
— It should be easy to raise from seeds or cuttings
— It should be drought tolerant
— It should have dense foliage, and preferably be thorny, and
— It should stand severe pruning to develop a thick and compact growth

Some of the plant species very useful as live fence are: *Duranta plumeri, Sesbania aegiptica, Inga dulcis, Prosopis juliflora,* etc.

To establish a live hedge, the soil along the fence is dug 50 cm wide and 50 cm deep at the commencement of the rainy season It is manured and prepared well for planting seed or cuttings. Care regarding watering whereve1 necessary shoul be taken for germination of seeds or for rooting of cuttings

Planting of Wind-breaks

Wind-breaks are rows of tall trees planted with close spacing around the orchard, towards the direction of the wind, to minimise damage due to winds such as uprooting of trees, breaking of branches, flower andd fruit drop and erosion of surface soil.

The planting of wind-breaks should precede that of the fruit trees by at least two years. The efficiency of the wind-break depends more on the height than its thickness.

The wind-breaks may pose problems sometimes, by competing with fruit trees for moisture and nutrients Hence, the first row of the wind-break may be planted at least 3 metres away in a 50 cm deep trench.

An ideal wind-break should be upright in growth and occupy as little space as possible. It should be tall, mechanically strong, quick growing and sufficiently dense in order to offer maximum resistance against wind, or two rows of such trees are planted usually 2 to 3 metres apart. Trees commonly grown as wind-breaks are, *Polyalthia longifolia, Casurina equisetifolia, Erithrina inddica, Grevillia robusta, Ddalbergia sissoo, Eucalyptus globulus,* etc.

Sometimes certain fast growing species are used to raise temporary wind-breaks. For example, *Sesbania aegiptica* is grown as a wind-break on the south western side of banana and papaya plantations.

Orchard Layout

Orchard layout refers to the positioning of trees, roads, and buildings in the orchard being established. Here, the fruit plants are planted in the plot at suitable distances for proper development and easy orchard operation It should also enable optimum utilisation of orchard space, supervision and management of the orchard, and provide scope for further extension. Therefore, the factors which are considered important for proper layout of the orchard are the system of planting and planting distance suitable for different fruit crops.

QUESTIONS

1 Why is orchard layout necessary?
2 What points should be considered while selecting the site for an orchard?
3. Why are fences and hedges planted?
4 What is a wind-break? Discuss its advantages and disadvantages.
5 Enumerate the points which require consideration while planning an orchard

CHAPTER 4

Planting Systems Followed in Fruit Culture

Introduction

For proper lay out of the orchard the system of planting and planting distance is considered important. The system of lay out refers to the orderly way of planting the trees which helps to carry out interculture operations. The other advantages are equal distribution of area under each tree, minimize wastage of land, aids easy and effective supervision, and scope for systematic expansion of the orchard. The lay out is to be decided after considering the topography of the land soil, and growth habits of plants.

Planting Systems

There are six systems of planting fruit trees. They are:

1. Square System,
2. Rectangle system,
3 Quinconx (diagonal) system.
4. Hexagonal system,
5. Triangular system, and
6. Contour system.

1. The Square system

The square system is the simplest and the most convenient of all the methods of planting. In this case, trees are set at the corners of squares formed by intersecting legnthwise parallel lines with crosswise parallel lines. Irrigation channels can run straight and intercultivation is easy as trees are planted at equal distances from each other in regular lines. Also, better watching of orchard is possible from one end to the other.

2. Rectangle system

In this method, trees are planted in straight rows running at right angles to one side of the field. The distance from plant to plant and row to row is not the same as in the square system and four trees joined at the base give a rectangle. Cultivation and irrigation can be done in two directions

3. Quincunx or diagonal system

The Quincunx or diagonal system resembles the square system but for the addition of a tree in the centre of each square, that is, at the points of intersection of the iagonals. This is known

as 'filler', which serves as a source of additional income till the main trees come to bearing It should be removed if it hinders the growth of the main plants in any way. Obviously fillers are planted when plant to plant distance is great and the plants are expected to come to bearing after a number of years. The main disadvantage of this layout is the difficulty encountered in intercultivation.

4 **Hexagonal system**

In this case, trees are planted at the corners of equilateral triangles. Unlike in the square system, the distance between the rows is less than the distance between the trees within the row. The system enables planting of 15 per cent more trees than the square system in a given area But this system is not commonly followed.

5 **Triangular system**

The triangular system is different from the square system in the sense that the trees in the even numbers rows are planted midway between but not opposite to the trees planted in the odd numbered rows This system is of less practical utility as the number of trees is less than in the square system and equal spacing cannot be maintained from all sides

6. **Contour system**

Hilly regions with a high degree of undulating topography are prone to soil erosion, whenever rainfall occurs or irrigation is carried out. So to check loss of top-soil due to erosion, contouring is done That is, terraces are marked at various heights from the mean sea level and the points having the same altitude are joined together by a line and the trees are planted along this contour at right angles to the slope. It also controls the rate of flow of irrigation water in the channels and thereby ensures better percolation of water, and least soil erosion. The width of the contour terraces would depend on the nature of the slope

Planting

Planting is carried out at the beginning of the monsoon. If the soil permeability is good the size of the pit is not important Also, it is of no use making pits larger than required to accomoodate the roots of the plants being planted. The top-soil should be kept separately for filling the pit on the surface, and the subsoil mixed with farmyard manure should be used for filling the lower half of the pit.

The plant should be planted about 10 cm higher than th ground level, as the soil tends to settle with watering It is necessary to press the soil around the plant and water well to avoid air pockets

Planting is done adopting the square system, unless there are good reasons for deviating from the system. Right angles are set out easily. Trees planted at five metres apart both ways would give a planting density of 400 trees per hectare.

Trees with lateral inflorescence, such as citrus and avocado, can be set out in a rectangular planting system.

Trees with circular crowns, such as palms, are best planted in an equilateral triangular system (hexagonal system) This allows cultivation in three directions and can accommodate 15 per cent more trees per hectare. However, the square system is usually preferred, because it allows intercropping both ways

Though the usual practice is to plant evergreen fruit trees like mango, sapota,

citrus, guava, etc during the rainy season (June-August), often planting is done during spring (February-March) too, provided there is adequate water supply As far as deciduous fruit trees are concerned, they are planted before the growth starts (during the dormant period) so that they are established before summer.

While planting, apart from the kind of fruit plant and local climatic conditions, the direction of rows must be considered In the tropics, the row direction would make little difference as there is ample sunlight, but in the subtropics preference is given to a north-south direction to avail the maximum advantage of sunlight. If the summer is too hot then shade should be provided to protect against sunburn. Tree trunks are painted with whitewash to minimise damage due to sunburn

Spacing of Fruit Trees

Plant density and spacing depend very much on the nature of the plant; thus a mango plant needs more space than a citrus plant and a pineapple plant can thrive well with much less space than bananas. Apart from this, soil and climate have to be considered too. Where water and nutrients are in short supply, more space per tree is necessary Trees which bear terminal inflorescence must not be crowded.

Overcrowded plants have to compete with each other for nourishment, water and light, and are subject to severe incidence of pests and diseases. As a result the cultural operations become difficult and such plants eventually will yield small sized fruits of inferior quality.

In a rectangular system, a spacing of 6 x 8 m instead of 7 x 7 m for citrus and avocado, will give more room for intercultivation between the rows and for intercropping during the initial years. Double or hedged row planting with a spacing of 3 x 8 m is also practiced in citrus. Usually the intention is to remove half the number of plants in each row when they start growing.

Selection of Plant Material

The choice of the plants determines the yield and quality of the produce and hence is the most important consideration. Elite plants of known quality should be secured. A little extra money spent on quality plants will pay in the long run

The plant material should be vigorous healthy, of genuine variety and free from pests and diseases. Planting material should always be procured from reputed private or government nurseries or firms. It is better, if possible, that the grower raise his own planting material from known trees having high productivity in his own orchard.

Too many varieties should not be planted in an orchard as they all may not be in good demand in the market. The variety selected should be one with good yield potential and quality fruit with consumer preference.

The optimum plant is one which is of medium size, as larger ones are liable to be damaged during transit and are difficult to establish One year old plants are ideal for planting.

Plants from the nursery beds should be lifted with as much ball of earth as possible in order to protect the roots, and wrapped with a wet gunny cloth and later with straw or a polythene film As

soon as the plants are received in the orchard, a few leaves should be removed to bring down transpiration, and it should be copiously watered and kept in the shade for a few days for curing, and planted out as early as possible

QUESTIONS

1 Discuss the importance of planting distance in fruit culture
2 Explain why removal of leaves is preferred before planting in certain plants?
3 Mention the special features of the contour system of planting
4 Which is the best planting season for plants? Give reasons.
5 Write short notes on
    i Hexagonal system
    ii Filler tree

CHAPTER 5

Mango

Introduction

Mango (*Mangifera indica L.*) is rightly called the 'King of Fruits' in India as it is one of the most favourite fruit found growing in all parts of the country. Among the fruit crops, the mango occupies the largest hectarage. It is associated with the history of agriculture itself, as mango has been under cultivation in the Indian subcontinent for well over 4,000 years. This fruit attained much prominence during the Moghul regime. It was during this period that the grafting technique was developed which has made it possible to retain the characters of a variety through vegetative propagation, and helped in the perpetuation of many commercial varieties.

Origin and Distribution

The mango is reported to have originated from Southeast Asia. Wild mango forests of *M. indica* and *M. sylvatica* are still found in Assam. Several other species are found in Southeast Asia and the Philippines. However, the highest concentration of *Mangifera* species is reported to be in the Malay Peninsula (19) followed by the Sunda Islands (16) and the Eastern Peninsula (14). All evidence indicates that the genus had its origin in the continental region of (i) Mayanmar, Thailand, Indo-China, and (ii) Malayan Peninsula. Since these happen to be the main centres of species formation, the Sunda Islands (Java, Sumatra and Borneo), the Philippines and the Celebes-Timor group form the secondary centres of development.

Botany

The mango is an erect, evergreen large tree, with a wide crown and it belongs to the family Anacardiaceae. In most varieties, the young leaves are red or coppery in colour, which later turn green and remain on the tree for over a year. The inflorescence contains thousands of flowers, some of which are male and others bisexual. The percentage of perfect flowers have been reported to vary from 1 to 75, depending on the variety. The fruit is fleshy drupe with an edible pulp and stony layer around the seed.

The plants are either monoembryonic (only one embryo in one seed) or polyembryonic (two or more embryos per seed) depending on the variety. Most of the Indian varieties are

monoembryonic. In a polyembryonic variety, out of the many seedlings that grow from one seed, only one is gametic and the rest are nucellar As the nucellar seedings are truly maternal and true to type, these are suitable for use as rootstocks also.

The mango seed rapidly loses viability if not properly stored and hence is best sown fresh. On germination it forms a long tap root which may go down very deep in pliable soil. Seedling trees are known to live as long as 90 to 100 years, while the grafted trees may live for 70 to 80 years.

Uses and Nutritive Value

Mango fruits can be consumed at all stages of maturity in various forms Young and unripe fruits because of their acidic taste, are utilised for culinary purposes as well as for preparing pickles, chutneys and *amchoor* Ripe fruits are utilised in preparing squash, nectar, jam, cereal flakes, custard powder and baby food, mango leather *ampapad* and toffee. Besides, fruits of some varieties like 'Alphonso' and 'Dasheari' are sliced and canned for use in the off season as well as for export

From the nutritional point of view, mango is a rich source of vitamin A and it also has a fair amount of vitamin C. The carotenoid pigments and beta carotene (provitamin A) increases with ripening, whereas vitamin C registers a sharp fall The fruit composition, in general, differs with the variety and stage of maturity. The ripe 'Alphonso' mango is reported to have 80 per cent moisture, 20 per cent Brix total soluble solids, 18 per cent total sugars, 80 mg vitamin C and 13,000 mg of B-carotene. The unripe green mangoes in some varieties are reported to have 90 per cent moisture, 0.7 per cent protein, 0.1 per cent fat, 8.8 per cent carbohydrate, 0.01 per cent calcium, 0 02 per cent phosphorus, 4 5 mg/100 g iron, carotene (as vitamin A) 150 i.u , 30mg/100g riboflavin and 30 mg/100g ascorbic acid.

Area and Production

In India, the mango occupies 30 per cent of the total area under fruits comprising of 1 01 million hectares producing 8 5 million tonnes of fruit. The state of Uttar Pradesh has the largest area under mango cultivation, followed by Andhra Pradesh and Bihar (Table 5.1).

Climate

The mango is very well adapted to tropical and subtropical climates and it thrives in almost all regions from sea level to an altitude of 1,500 m However, it cannot be grown on a commercial scale in areas above 600 m. It cannot stand severe frost especiallly when the tree is young. High temperature alone is not injurious to mango, but if accompanied by low humidity and high winds, it affects the trees adversely.

Most of the mango varieties thrive in places with good rainfall ranging from 75 to 375 cm per annum and a distinct dry season. However, the distribution of rainfall is more important than its amount. Rainfall during flowering is detrimental to the crop as it interferes with pollination and also promotes diseases. Dry weather before flowering is conducive to profuse flowering Strong winds and cyclones during the fruiting season can cause havoc and destroy the crop completely.

Soils

Mango is found growing in several types of soils such as lateritic, alluvial, sandy loam and sandy soils. Although it grows very well in soils of high to medium fertility, its cultivation can be successfully done in less fertile soils by providing good management especially in the early stages. The loamy, alluvial, well drained and deep soils with a high percentage of humus are ideal for mango cultivation. Extremely sandy, shallow, rocky, waterlogged and alkaline or calcareous soils are not suitable for mango cultivation.

Table 5.1 : Area and Production of Mango in India

State	Area (ha)	Production (t)	Productivity (t/ha)
Uttar Pradesh	2,50,601	16,57,094	6.6
Andhra Pradesh	1,93,086	23,17,032	12.0
Bihar	1,44,204	15,42,040	10.7
Kerala	72,418	2,25,934	3 1
Karnataka	68,100	6,46,269	9.5
West Bengal	54,600	4,07,900	7 5
Tamil Nadu	54,450	5,44,500	10 0
Orissa	48,176	2,67,00	5.5
Maharashtra	35,000	1,45,140	4 1
Gujarat	32,000	3,20,000	10 0
Other states and UTs	1,22,469	4,31,583	3 5
Total	10,10,304	85,04,492	8.4

Source: Hort Statistics, National Horticulture Board, Gurgaon (1989-90)

Varieties

There are nearly 1,000 mango varieties under cultivation in India Of these, there are only about 20 varieties grown on a commercial scale. Statewise distribution of commercial varieties of mango in the country is presented in Tables 5 2 and 5.3

Table 5.2 : Important Mango Varieties Cultivated in Different States of India

State	Varieties grown
Andhra Pradesh	*Alampur Benishnn, Banganapalli, Bangalora, Cherukurasam, Himayuddin, Swarnarekha,*
Bihar	*Bathua, Bombai, Himasagar, Sukul, Fajri.*
Goa	*Alphonso, Fernandin, Mankurad.*
Gujarat	*Alphonso, Kesar, Rajapuri, Vanraj,*
Haryana	*Dasheri, Langra, Sarauli.*
Karnataka	*Alphonso, Bangalora, Mulgoa, Neelum, Pairi.*
Kerala	*Mundappa, Olour, Pairi*
Madhya Pradesh	Mostly seedling types and *Alphonso, Bombai, Langra.*
Maharashtra	*Alphonso, Mankurad, Mulgao, Pairi*
Orissa	Mostly seedling types and *Benisnn, Langra, Neelum, Swarnarekha.*
Punjab	*Dasheri, Langra, Same Bihisht Chausa*
Tamil Nadu	*Banganpalli, Bangalora, Neelum, Rumani, Mulgoa.*
Uttar Pradesh	*Bombay Green, Dasheri, Fajri, Langra, Safeda Lucknow, Same Bihisht Chausa*
West Bengal	*Bombai, Hemsagar, Langra, Zardalu.*

Table 5.3 . Regional Distribution of Commercial Varieties Grown in India.

Region	*Varieties grown*
Eastern	*Himsagar, Fajri, Langra, Bombai*
Western	*Alphonso, Pairi, Kesar, Rajapuri.*
Northern	*Dasheri, Langra, Bombay Green, Chausa.*
Southern	*Neelum, Banganapalli, Bangalora, Mulgoa, Swarnarekha, Badami, Raspuri.*

Chracteristics of some of the important varieties are indicated below:

(i) *Alphonso:* This is the leading commercial variety of Southern and Western India and one of the best varieties of the country. This variety is known by different names in different regions viz , *Badami, Khader, Apus, Hapus* and *Kagdi Hapus.* The fruit is medium in size, ovate oblique in shape and orange yellow in colour. The fruit quality is excellent. It is a mid-season variety. It has been found highly suitable for canning purposes and is maninly exported to other countries However, it is an alternate bearer and is susceptible to "Spongy Tissue" disorder.

(ii) *Pairi·* Pairi is an important South Indian variety, especially in Karnataka and Maharashtra States. It is an early variety. The fruits are medium in size excellent in taste and flavour, but hhighly susceptible to powdery mildew

(iii) *Bangalora: Bangalora* is a commercial variety of South India. The common synonyms of this variety are *Totapuri, Kallamai, Collector, Sundersha* and *Gilli Mukku.* The fruit is medium to large, oblong with nicked base and the colour is golden yellow. Fruit quality is poor but has very good shelf-life. it is a mid-season variety and extensively used in processing.

(iv) *Dasheri:* This variety derives its name from the village Dashehari, between Lucknow and Malihabad in Uttar Pradesh. It is a leading commercial variety of North India and one of the best varieties of the country. The fruit size is small to medium, the shape is oblong to oblong oblique, with a yellow pulp. The fruit quality is excellent. It is a mid-season variety with good keeping quality. It is mainly used as a table variety

(v) *Neelum:* This is a regular bearing commercial variety, indigenous to Tamil Nadu It is an ideal variety for transportation to distant places owing to its high keeping quality. The fruit is medium in size, ovate oblique and saffron yellow in colour. Fruit quality is good. It is a late variety.

(vi) *Mulgoa·* This is a commercial vanity of Southern India. It is very popular owing to the high quality of its fruit. The fruit is large in size roundish oblique and yellow in colour. The fruit quality and keeping quality are good. it is a late season variety.

(vii) *Mundappa:* A popular variety of Dakshin Kannada District. The plant bears large-sized fruits with a small stone and is of excellent quality.

(viii) *Langra:* This variety is indigenous to Varanasi areas of Uttar Pradesh. It is extensively grown in Northern India. The fruit is of medium size, ovate and lettuce green in colour. The fruit quality is good but keeping quality is medium. It is a mid-season variety.

(ix) *Banganapalli:* A commercial

variety of Andhra Pradesh and Tamil Nadu. It is also known as *Chapta, Safeda, Ganeshan* and *Chapatai.* The fruit is large in size and obliquely oval in shape. The colour of the fruit is golden yellow. The fruit and keeping quality are good It is a mid-season variety and is good for canning also.

(x) *Amrapalli: Amrapalli* is a cross between *Dasheri* and *Neelum.* It is a dwarf, regular, late and rich in vitamin A content. The plant bears medium sized fruits of excellent quality and is a prolific bearer. Because of it dwarf stature it is ideally suited for high density orcharding.

(xi) *Mallika·* It is a cross between *Neelum* and *Dasheri* varieties of mango In Karnakata it has acclimatized itself and has a regular bearing habit. The fruit size is medium, oblong to elliptic in shape and cadmium yellow in colour. The fruit quality is excellent and has a good shelf-life. It is a mid-season variety.

In addition, a hybrid between *Neelum* and *Alphonso* named *Ratna* has been released from Maharashtra Regularity in bearing and freedom from spongy tissue have been claimed as its significant attributes.

Propagation

Mango can be raised from seed or propagated vegetatively. Propagation from seed, though easy and cheap is undesirable as it is unable to perpetuate characteristics of the parent tree, because most commercial varieties in India are highly cross pollinated and monoembroynic Plants also take more time to bear fruits. Hence, several methods of vegetative propagation have been tried with varying degrees of success. To raise seedlings for use as rootstocks, however, stones should be sown in June-July in beds mixed with well rotted farmyard manure at the rate of 8-10 tonnes per hectare. Alternatively, 25 kg nitrogen per hectare may be applied in the form of urea or calcium ammonium nitrate (CAN) or in any other available inorganic source in two split doses at about two months interval after the leaves have become green. When the seedlings attain the age of 2-3 months, they are transplanted in pots or polythene bags. Proper care should be exercised in irrigating the young transplanted seedlings.

Stock plants are generally propagated using stones from seedling trees and thus there is a variation in their stonic influences. The polyembryonic rootstocks, however, have shown promise in producing plants of uniform size and vigour. Apart from this, these rootstocks have indicated the possibility of inducing dwarfing and earlier bearing. Various asexual methods employed in mango propagation such as inarching, veneer grafting, budding, stone grafting and soft wood grafting are preferred by the nursery men for their high rate success and ease in handling.

Planting

Prior to planting, the field should be deeply ploughed and harrowed. Pits of proper size should be dug at appropriate distance generally at 10 x 10 m and, filled by adding sufficient quantity of farmyard manure. The grafts should be procured from reliable nurseries for planting.

Time of planting

The best time for planting in the plains

is during the monsoon when there is sufficient humidity in the atmosphere However, in heavy rainfall area the best time of planting mango is at the end of the rainy season, whereas, in tracts where the rainfall is less, the planting can be done in the early part of the monsoon for better establishment. The planting should be done in the cool hours of the evening, otherwise if the day turns out to be unusually hot or dry, the plants may wither due to excessive transpiration

Planting Distance

The planting distance may vary according to variety, fertility level of the soil and general growth conditions in the area. However, as most of the grafted fruit trees develop medium tree stature a spacing of 10 x 10 m will be enough for their proper growth and development.

Size of Pits

In locations where the soil is loamy and deep, pits of 0.75 m^3 should be dug 10 m apart, whereas in shallow and hilly areas the pits should be atleast 1 m^3 in size.

Filling of Pits

The pits should be refilled with the regional surface soil mixed with 20-25 kg well rotted farmyard manure, 2 5 kg superphosphate and one kg muriate of potash per pit In the top two-thirds portion, the proportion of manure and soil may be in the ratio of 1·3. If the soil has an infestation of white ants, 100 g Chlordane or Aldrin 5 per cent may be mixed with the top-soil in the pit bfore planting.

In rocky areas, it is better to remove all the stones from the excavated material and only good soil should invariably be filled before the monsoon, so that there is maximum settling down of the loose soil before the advent of heavy rains

Planting of Grafts

The grafted plant, with its ball of earth taken out of the pot or polythene bag, should be placed in the centre of the pit with the help of a planting board, by excavating as much soil as necessary to accommodate the root ball. The soil of the pit is then pressed around the root ball. A small basin is made and the plant is properly watered The planting should not be done so deep as to bury the graft-union in the soil or so high as to expose the upper roots. It is always better to plant it at the same level at which it was in the pot or the polybag.

Interculture

Interculturing in mango orchards is necessary not only to remove the weeds which compete with the main crop for water and nutients but also to ensure aeration which is so essential for the proper development of roots and shoots. Light hoeing also helps in better penetration of rain water and serves the purpose of mulching. However, frequency will vary with the season and age of the orchard.

Intercultural operations are important for the bearing mango orchards The first intercultivaion should be done with the onset of pre-monsoon showers. This helps in checking run-off losses and facilitates the maximum percolation of water in the soil. The orchard may be ploughed again after the rainy season is over during October so

as to suppress the weed growth The third cultivation may be done in the first week of December to check mealy bugs.

Training and Pruning

Normally mango trees require very little or almost no pruning. However, the training of the plants in the initial stages is very essential to give them proper shape. Specially when the graft has branched too low, the process of training becomes very important. The training is done in such a way that at least 75 cm of the main stem (from the ground level) is kept free from branching and the first leader/main branch is allowed to grow after that The main branches should be spaced in such a way that they grow in different directions and are at least 20-25 cm apart, otherwise there are chances of breakage due to smaller crotch angles and a heavy top.

The branches which exhibit a tendency for cris-crossing each other should be discouraged whenever observed otherwise they may break by rubbing against each other at a later stage and create complications. Secondly, if the centre is closed, the fruits produced are of poor quality due to poor coloration in the absence of sufficient sunlight.

By proper training there will be almost no need for future pruning, except for removal of diseased or dried shoots.

Intercropping

Keeping in view the spacing and growth of mango plants, considerable inter-space remains unoccupied from the initial stages up to a period of 8-10 years. Hence, to utilize the land and other resources profitably, various crops could be raised successfully in young orchards. If the intercrops are selected and grown carefully by adopting recommended package of practices, not only can the fertility status of the soil be maintained, or even improved, but it will also help in fetching additional returns to the growers. However, selection of the intercrop depends upon the soil type, locaion, marketing facilities and levels of inputs and management available, etc. It is always advisable to avoid tall growing exhaustive crops like maize, sugarcane, bajra, etc. Some fertility restoring crops like legumes, should be incorporated in the intercropping rotation. Even in fully grown up or old orchards certain crops like pineapple, ginger, turmeric, etc, which can tolerate partial shade, can be grown In addition to field crops, some short duration, less exhaustive and dwarf fruit crops can also be grown. Some of the fruit crops which are suited for this type of intercropping are guava, *phalsa*, custard-apple, etc, and these may be grown depending upon the regional demand and other local considerations.

Fertiliser Application

Although the mango grows well even in poor soils, because of its deep root system but between of the vegetative growth and the yield potential that it has to attain, as well as nutrients removal from the soil through crop harvest, adequate manuring should be done regularly to maintain the soil fertility and to increase production Nutritional requirements vary with the region, depending upon the type of soil and age of the plantation

Quantity of Fertilisers

Application of manure and fertilisers to mango plants should start right from

planting in the field The first application is made at the time of filling the pits. The following fertiliser application, at the rate of 75:20:20 g NPK/plant/year i.e. 170 g urea, 115 g super-phosphate and 115 g muriate of potash per plant, is recommended during the first year of planting.

This dose should be increased every year up to ten years in multiples of the first year's dose, Thus a ten year old tree would receive 750:200:700 g NPK/tree or 1.7 kg. urea, 1.12 kg single super-phosphate and 1.14 kg of muriate of potash per year.

Time of Fertiliser Application

Fertiliser may be applied in two split doses, one half immediately after harvesting of fruits in June or July, and the other half in October for both young and old orchards, synchronising with the onset and withdrawal of rains respectively.

Method of Fertiliser Application

After rmoving the weeds from the basins, the recommended dose of fertilisers is mixed thoroughly with the soil and applied in a ring (15-20 cm deep) under the canopy of the plant, leaving about 45-60 cm from the tree trunk in old trees,

Irrigation

Mango being a hardy dry land crop, it is mostly grown under rained situation and not normally irrigated. In the first year however, when plants are very young with a shallow root system, providing protective irrigation during the summer months is desirable to minimise mortality. Adoption of water harvesting techniques like contour bunding, fall ploughing, etc, will help in better conservation of rain water. When trees are in the full bearing stage, providing two to three irrigations after the fruit set has been found to be beneficial in getting higher yields.

Flowering and Fruiting

The seedling mango trees, because of their long juvenile period, come to flowering 6-8 years after planting, whereas the grafts will start flowering and fruiting from the third year It is desirable to remove all the flowers and fruits until the trees are four to five years old, if one desires to have large sized and long lived trees. If dwarf trees are required they may be allowed to flower, which would help to check the vegetative growth of the trees thus dwarfing the tree. A plantaion starts yielding economical returns from 8-10 years onwards.

The period of flowering in mango may vary, depending upon the climatic conditions of the region. In South India, the mango starts flowering during December-January, whereas under North Indian conditions flowering is as late as the first week of March and extends upto the middle of April. Depending upon the variety, mango fruits are ready for harvest in about 90-120 days after the onset of flowering.

Use of Plant Growth Regulators

Plant growth regulators modify plant growth in different ways and they can be used to the advantage of fruit growers. In mango these chemicals are of use in the following aspects:

(a) Control of Flowering

Paclabutrazol (Cultar) can be used for inducing regular bearing in irregular bearing varieties This chemical is applied at the rate of 20 ml/tree after mixing in 20 litres of water in the root zone of tree in the middle of August.

(b) Control of Fruit Drop

Auxins like Naphthalene Acetic Acid (NAA) and 2,4 - D can be sprayed at 20 ppm concentration at marble stage of fruits to check their drop.

(c) Control of Malformation

Mango malformation to some extent can be controlled by spraying NAA 200 ppm at the time of flower bud differentiation.

(d) Extension of Shelf-life

Gibberellic acid of 150 ppm can be used as a prepacking dip for extending the shelf-life of mango fruits.

(e) Fruit Ripening

Ethylene gas can be used at the rate of 1,000 ppm for inducing uniform and early ripening in mango. Prepacking dip in Elthephon 1,000 ppm is also equally effective for inducing ripening in mango.

These chemicals should be used only when necessary. The correct concentration timings and methodology should be used or the results may be detrimental to ripening.

Plant Protection

a. Major Pests and Their Control

Mango trees are reported to be attacked by more than 350 species of insects, eight species of mites and 13 species of nematodes all over the world. Of these, nearly 50 per cent have been reported from India. However, the major pests which cause serious losses are hoppers, mealy bugs, fruit fly, shoot and stem borers, shoot gall psyllids, stone weevil, leaf webber, blossom midges and leaf gall midges.

A brief description of the biology and control of these major insect pests is indicated below:

(i) Hoppers (*Idioscopus* spp. and *Amritodus atkinsoni*)

Of all the insect pests attacking mango, hoppers are the most serious and widespread in the country. Although they are present in the orchards throughtout the year, they are at their peak during the flowering season. Due to heavy sucking of buds and mid-ribs of the leaves, the buds get distortaed and dry up and the leaves become curled. Damage is caused both by the nymphs and adults by sucking the sap from the inflorescence, as a consequence of which the inflorescences dry and fruits, if any, drop prematurely. Shade and high humidity which are common in old, neglected and densely planted orchards are favourable for their incidence and build-kup.

Spraying of Carbary Sevin at 0 15 per cent two to three times, or Monocrotophos (Nuvacron) at 0.14 per cent or Dimethoate (Rogor) at 0 05 per cent at monthly intervals, are found effective in controlling this pest. The first spray is to be done when the panicles have just emerged but flowers have not yet opened, and the second and third spray is done when the fruits are of

peanut size and subsequently when the popluation of hoppers is high. Two pre-bloom sprays and one bloom spray at fruit set are highly effective. Spraying should, however, be avoided at full bloom stage to avoid the washing away of pollen and hindering the activity of insects in pollination

(ii) Stone Weevil (*Sternochetus mangiferae*)

Weevils lay eggs on fruits and the grubs enter the nut and feed in it, Pupation takes place inside the nut and the emergaing adult cuts through the nut and the pulp All the varieties except *Dasheri* have been found susceptible, though, the extent of damage varies. this is also one of the limiting factors in export of fruits. For its control, three sprays of Fenthion 0.1 per cent are recommended at monthly interval starting from 1½ months from flowering.

(iii) Mealy Bug (*Drosicha mangiferae*)

This is another major pest of mango and is widely distributed all over the country. Small (1-2 mm in length) pink to brown coloured first instar bugs, after hatching from eggs in the soil, start migration to mango trees from he last week of Decomber. They crawl up the tree and settle on the tender leaves and inflorescence and start feeding by sucking the sap, as a result of which the flower panicles wilt and dry

For controlling this pest, 2 per cent Methyl Parathion dust (at the rate of 250g/tree) should be mixed with the soil near the tree trunk in the third week of December to kill newly hatching nymphs. After this a 20 cm wide alkathene strip (400 gauge) should be fixed on the tree trunk in the last week of December before the mealy bugs start migrating. A small quanity of grease should be applied on the lower edge of the band so that it acts as a barrier to the first instar bugs. Banding should be done on all the trees in the orchard including other fruit crops, if any like guava, jackfruit and citrus

In case the above mentioned schedule is delayed or not followed, and the bugs have already migrated to the trees, two sprays of Phenthoate (Fallan) at 0.75 per cent or Monocrotophos (Nuvacron) at 0.04 per cent, or Allicin (synthetic garlic oil) at 0.45 per cent are recommended at 15 days interval to check their spread and damage.

(iv) Fruit-Fly (*Dacus dorsalis*)

The oriental fruit-fly is one of the most serious pests of mango in the country and has created considerable problems in the export of fresh mangoes. The maggots causes rotting of the pulp and the fruits drop.

The adult fruit-flies can be controlled by bait sprays of Carbaryl (Sevin) at 0.28 per cent + 0.1 per cent protein hydrolysate or molasses starting at pre-oviposition stage (first week of April) This spray should be repeated after 15 days.

Another method to control the incidence of fruit-fly is to hang traps containing 100 ml emulsion of Methyl Eugenol at 0.1 per cent + 0.1 per cent Malathion from April to June in the mango orchards About 10 such traps are sufficient to control the pest in one hectare of orchard. The should be done on a community basis.

(v) Shoot Borer (*Chlumatia transversal*)

The caterpillars bore through young

shoots and inflorescences affecting the growth of the plants adversely. The adult moths are shining and gray coloured, and measure about 1.75 cm with expanded wings. After hatching, the caterpillar enters the mid-rib, and finally the young tender shoots near the growing tip and tunnel 10-15 cm downward. The affected shoots start wilting and ultimately dry.

The pest can be controlled effectively by spraying with Carbaryl (Sevin) at 0.2%, or Quinalphos (Ekalux) at 0.05%, or Monocrotophos (Nuvacron) at 0.04% at fortnightly intervals from the commencement of a new flush. A total of two-three sprays are sufficient to control the pest

(vi) Bark Eating Caterpillar *(Indarbela quadrinotata)*

This pest is found all over the country and is a serious problem in old shady and neglected orchards, especially those surrounded by forests. The full-grown caterpillar is about 3.5-4.5cm in length and a dirty brown in colour There is only one generation in a year The caterpillar spins a brown silken web on the tree. It feeds on the bark, disrupting the translocation of sap and the tree becomes weak. For the control of this pest, the webs from tree trunks are removed and one tablet of Phosotoxin or 0.05% emulsion of Monocrotophos (Nuvacron) is placed in each hole and plugged with mud paste.

(vii) Stem Borer (*Batocera rufomaculata*)

The damage is caused by the grubs feeding within the stem and boring upwards. Adult beetles are 3.5-5cm in length and grayish brown in colour with brown and black dots. The pest is most active during July-August and can be effectively controlled by following the recommendation given for the control of the bark eating caterpillar.

(viii) Shoot Gall Psylla (*Apsylla cistellata*)

This is a very serious pest of mango particularly in the Terai region of Uttar Pradesh and other parts of North India, It causes green conical shaped galls in leaf axils of mango starting from August. Affected buds fail to put forth inflorescences.

The pest can be controlled by spraying 0.05 per cent Monocrotophos (Nuvacron), or 0.06 per cent Dimethoate (Rogor), or 0.05 per cent Qunialphos (Ekalux) at three weeks interval from the middle of August.

(ix) The Mango Leaf Webber (*Orthaga euadrusalis*)

The mango leaf webber Iras in recent years become an important pest for the mango in Uttar Pradesh, West Bengal and Karnataka, Infestation of this pest begins from June and continunes up to December. The adult moths which are medium sized and anber coloured, lay their eggs on the leaves. the first instar larvae which hatch, feed on the chlorophyll. From the second instar onwards they start webbing the leaves and feed on the entire leaf, leaving behind the midrib and veins.

Pruning infested shoots and burning them in the months of June kand July, help a lot to minimise the pest population. Raking the soil around the base of the tree in January after the last generation has pupated also helps in controlling the

pest. the insecticides recommended for the control of this pest are Carbaryl (Sevin) at 0.2 per cent or Monocrotophos (Nuvacron) at 0.2 per cent or Quinalphos (Ekalux) at 0.05 per cent. Threee sprays from the last week of July at 15 days interval are effective in managing this pest.

(x) Blossom Midge (*Erosomyia indica*)

The blossom midge attacks inflorescence buds, panicles, and newly formed fruits. The attack of midges on panicles and on small fruits causes severe loss.

Spraying of Dimethoate (Rogor) at 0.45 per cent, or Diazionon at 0.04 per cent at the panicle emergence stage is quite effective in controlling the pest.

b. Major Diseases and their Control

Some of the major diseases of mango causing loss and their control measures, are below:

(i) Powdery Mildew (*Oidium mangiferae*)

Powdery mildew is one of the serious diseases of mango affecting almost every variety The disease appears mostly during February-March and sometime earlier due to congenial temperature and humidity in North India, whereas in Southern and Western India it appears during December-January. Warm humid weather and cool nights favour the spread of the pathogen.

A white, powdery growth of the fungus may be seen on the flowers, fruits and leaves. The flowers cease to grow, fail to open and shed. Newly set fruits may be covered entirely by the mildew. As the fruits grows, its epidermis in the infected area cracks, and corky tissues are formed. The infected fruits usually drop after attaining pea size. Young leaves are attacked mostly on their upper side and the infection is frequently restricted to the area of the central rib. Affected leaves curl and become distroted. The disease can be kept under control be spraying the crop soon after flowering two to three times with Sulfex (0.2 per cent) at an interval of 3-4 weeks depending upon the wealther and incidence of disease

(ii) Anthracnose (*Colletrotric um gloeosporioides*) Perfect Stage (*Glomeruli cingulata*)

The Anthracnose disease is of widespread occurrence and capable of causing serious losses under favourable climatic conditions of high humidity, frequent rains and temperature of 24-32°C when young shoots, flowers or fruits are produced. It is also known to occur during the storage of fruits, wither tip, twig blight and fruit rot symptoms. Tender shoots and foliage are readily affected, finally resulting in the "die back" of young branches. Older twigs may be infected through wounds and may be killed. The fungus also attack inflorescence and young and mature fruits. Black spots develop on the panicles and fruits. Severe infection may destroy the entire inflorescence and no fruit set occurs Young infected fruits develop black spots, shrivel and drop off. The incipient infection at the maturity stage will carry the fungus into storage, transit and marketing stages The fungus perpetuates on twigs and leaves of mango and other hosts.

The diseased twigs should be pruned and burnt along with fallen leaves for

reducing the inoculum potential. Trees may be sprayed with Bavistin (0 1 per cent) twice during flowering at and at intervals of 14 days. Instantaneous dipping of fruit in Bavistin soloution (1,000 ppm) before storage has been found to reduce the incidence of the disease.

(iii) Phoma blight (*Phoma glomerate*)

The symptoms of the disease are noticed only on old leaves. Initially, the lesions are minute, irregular, yellow to light brown and scattered alll over the leaf lamina. As the lesions enlarge, their colour changes from brown to cinnamon and these become almost irregular. Fully developed spots are characterised by dark margins and dull grey necrotic centres. In case of severe infestation such spots coalesce, forming a patch which may measure 3.5-13 mm in size, resulting in complete withering and defoliation. Such plants can easily be observed from a distance.

The disease can be effectively controlled by spraying Copper oxychloride (0.3 per cent) at fortnightly intervals

(iv) Die Back (*Botryodiplodia theobromae*)

This is one of the serious diseases of mango. The effect of the disease on the general appearance of the tree is noticeable at any time of the year but is most conspicous during October-November. The disease is characterised by drying of branches and twigs followed by complete defoliation and the tree gives and appearance as if it has been scorched by fire.

Measures like (a) selection of scion from healthy trees, (b) sterilisation of grafting knives, (c) placement of grafted plants in dry environment, and gradual exposure to full sunlight, help in keeping the disease under check. Pruning of diseased twigs, followed by spraying of Bordeaux mixture (5:5 50) or pasting with Bordeaux paste helps in minimising the incidence of dieback.

(v) Bacterial Canker (*Xanthomonas campestris mangiferae*)

Canker is becoming a serious disease of mango in India. The disease attacks leaves, leaf stalks, twigs, branches and fruits, initially producing water soaked lesions and later turning into typical cankers On leaves the disease first appears as minute water soaked irregular lesions usually crowded at the tips. Initially the lesions, are small and light yellowish in colour, but with age enlarge and turn dark brown. They become angular, cankerous and raised, and are surrounded by chlorotic halos. Several lesions coalesce to form irregular necrotic cankerous patches. In severe infections, the leaves turn yellow and drop off. On fruits, the initial water soaked lesions gradually develop into cankers, they often burst open, releasing a gummy ooze containing bacterial cells which is highly contagious. On branches and twigs, the fresh lesions are water soaked which later become raised and dark brown with longitudinal fissures but without any gummy ooze.

For checking the spread of this disease, seedling certification and orchard sanitation are suggested. Monthly spraying of Bavisting (0.1 per cent) followed by Agromycin (100 ppm) has been found effective in areas where incidence of bacterial canker is severe.

Harvesting and Post Harvest Handling

The time of harvest in mango varies with the variety and climatic conditions. Depending upon the variety, the period required for maturity of the fruits varies from 90-120 days after flowering. In South India, where flowering is early, the fruits are ready for harvest by the first week of May, and extending upto the end of June, whereas in North India because of late flowering, the fruits are ready for harvest by the beginning of June extending up to the middle of August

Stage of maturity

The stage at which the fruits should be harvested has an important bearing on the ripening and quality of fruit The various criteria recommended for judging the maturity are (i) slight colour development of the shoulders, (ii) prominent development of lenticles. (iii) natural fall of one or two ripe fruits from the plant, and (iv) when the specific gravity of the fruit ranges from 0 01 to 0.02 The number of days taken by the fruit to mature depends on the variety and the climatic conditions and hence cannot serve as a guide.

Of the above listed criteria, the specific gravity method is more dependable. For this, fruit samples from various directions of the tree are taken and dropped in a bucket of water, the sinking fruits being indicative of optimum maturity.

Methods of Harvesting

The present practice of harvesting in general is still primitive as the fruits are harvested by shaking the branches which results in damge to both the tree branches and fruits Climbing the tree with a collecting bag and plucking the fruits is a more satisafctory method, though some times impractcable. The most satisfactory method available now is the use of a bamboo pole with a circular ring fastened at the end to which a small thread net and cutting shear is attached. After cutting the pedicel of each fruit, it automatically gets collected in the net which is provided just below the cutting shear

Yield

The grafted trees start bearing at the age of five years (15-20 fruits) and the optimum yields starts from the 9th to 10th year onward, when each tree would yield about 400 to 500 fruits, depending on the variety The yield continues to increase upto the age of 35 to 40 years (2,500 fruits) after which it starts declining, However, in certain grafted varieties, like *Langra* and *Chausa*, the full bearing potential is realised much later (15-20 years) than in a variety like *Dasheri* (10 years) In a fully matured mango tree, depending upon the age and spread of the tree, the total number of fruits harvested may range from 1,000 (250 kg) to 2,500 (625 kg). In our country the average production of mango is only 8.5 tonnes/ha which is much below the potential. It needs to be improved through efficient management

Packing and Transport

The fruits should first be graded according to size and appearance soon after harvesting although this is not the usual practice.

Proper packaging is an essential

prerequisite for maintaining good appearance and quality of the produce on reaching the market centres. The most common practice in Western India (Malda) is to pack 50 to 100 fruits in bamboo baskets. Sometimes, straw is used as cushioning material to avoid injury to the fruits. Fruits of hardy varieties like *Bangalora* are often loaded directly into the railway wagons. However, one should bear in mind that for distant markets, fruits are packaged when still unripe. Besides bamboo baskets, wooden crates of various dimensions, depending on the variety to be packed, are also used. These boxes have perforations of 1.25 cm diameter on all sides. As wood is becoming scarce, emphasis is now being laid on utilising corrugated cardboard boxes which are not only lighter in weight but also can be recycled. Such containers are also now being used exclusively for export purposes, where individual fruits are wrapped in tissue paper, and cushioning is provided by putting additional paper shavings or wood wool.

Storage

The mango fruits ripen after harvest and hence have to be stored properly. Many varieties can be stored for 4 to 7 weeks at a temperature between 12^0 and 13^0 C. The fruit can also be treated with an aqueous wax emulsion which helps in reducing the fruit weight loss and spoilage.

Ripening

Usually fruits ripen in about five days under tropical conditions. The usual pratice is to place the fruits in layers, one over the other, with a straw padding in between two layers. This is usually done in closed but well ventilated rooms or godowns. A temperature of 19.4 to 21.1^0 C during ripening is found to be congenial for development of high T.S.S., reduction of acidity and for improvement of ascorbic acid retention. Storage in saw dust or mango leaves has also been found useful.

Other methods of ripening are artificial, using special chemicals or exposing the fruits to gases like acetylene and ethylene. These improve the fruits colour but the fruit quality is imparied, if fruits are immature.

Marketing

In most parts of the country, the usual practice is to auction the orchard to contractors at the time of flowering. The contractors are quite often financed by the commission agents or they themselves send the produce to leading commission agents through forwarding agents. Sometimes, the original contractor also passes on the orchard to sub contractors and makes some money in the process. Thus, the consumer pays a high price for the fruits, it spite of the fact that the grower gets a very low price for his produce owing to several middlemen operating in the process. Hence, there is an urgent need for organised marketing by growers through their own cooperatives to ensure better returns to the growers. Such societies are working well in Gujarat.

Special Problems and Measures to Overcome Mango Malformation

Mango malformation is widely distributed in India, though the incidence is more in the Northwest than in the Northeast or South. The problem is more serious in

Punjab, Delhi and Western U.P. where more than 50 per cent of the plants are affected by malformation. Almost all the commercial varieties of mango of North India are reported to be highly susceptible to malformation. It also has a profound influence on the sex expression in mango because malformed panicles mostly produce male flowers and hence no fruit is produced on these panicles.

Various control measures such as pruning of diseased portions, use of fungicides, acaricide, and plant growth regulators, individually and in combination have been tried with some success. One spray of 200 ppm NAA or Planofix in October followed by deblossoming at the bud burst stage is found to be effective in reducting the incidence of malformation. In addition, such panicles should be pruned in April and burnt. Some interesting results have also been obtained with the spray of Glutathione (2.24 g/h) ascorbic acid (2 11 g/1) and Potassium metabisulphite (0.14 g/1) for the control of mango malformation.

Biennial Bearing

The phenomenon of bearing satisfactory crop of mango once in two years is a serious problem causing tremendous loss to the mango industry in the country. Most of the commercial varieties namely, *Dasheri, Alphonso, Pairi, Malgoa, Langra, Chausa,* are prone to biennial bearing, but varieties like *Neelum* and *Bangalora* are regular bearers. In addition there are certain varieties, such as *Allampur Baneshan* and *Himayuddin*, which although excellent in fruit quality, have a shy bearing habit.

Biennial bearing has been attributed to lack of new growth and insufficient carbohydrate and nitrogenous reserves following heavy cropping in the 'on' years. Several attempts have been made to induce flowering in the lean years with the help of cultural practices and use of plant growth regulators, but with very little success. Recent work to overcome alternate bearing has shown the possibility of using an anti gibberellin biosynthesis compound-Paclabutrazol (Cultar). Application of 20 ml Cultar per tree after mixing in 20 liters water is recommended for application to the root zone in the middle of August for the control of biennial bearing. This has been found very effective.

Fruit Drop

The problem of fruit drop in some of the commercial varieties of mango is quite serious and causes great loss to the mango growers. A tree producing several thousand panicles, yields only a few hundred fruits and most of the flowers falling down after full bloom or at later stages of development. The phenomenon of fruit drop in mango has been divided into three distinct phases, namely, pin head drop, post-setting drop and May drop. Fruit drop at the initial stage is regulatory but May drop is serious and requires control.

Fruit drop has been attributed to many causes such as abortion of embryo, degeneration of ovules, depletion of nutrients, hormonal imbalances, etc. Fruit drop can be minimised by spraying NAA or 2.4-D (20 ppm) along with 2 per cent urea when fruits are of pranut size.

Black Tip

The black tip disorder of mango fruits, in which the tissue at the distal end dies during the early stages of development is a very serious problem in orchards located in the vicinity of brick kilns. The

affected fruits become unmarketable resulting in almost total loss of the crop depending upon the number of brick kilns and their proximity to the orchard. The fumes that come out of the brick kilns as a result of burning of coal contains carbon monoxide, ethylene and sulphur dioxide. All these gases are toxic to the young developing fruits of mango but the acidic fumes of sulphur dioxide are the most harmful in accentuating this disorder

The loss due to black tip is normally very serious in orchards located within 3-4 km from the brick-kilns. But during very dry weather conditions (April-June), the damage is more severe and is also noticed in orchards located as far away as 8 km from the brick kilns. The incidence of black tip may be minimised by the spray of boron (0.5per cent) and other alkaline solution like washing soda and caustic soda (0.8 per cent). The first spray of borax (0 5 per cent) may be given at peanut stage of the fruit and subsequently two sprays of borax (1%) may be done at 15 days interval. Some sticker or washing soap could be added to the spray solution. The stage of application is, however very important.

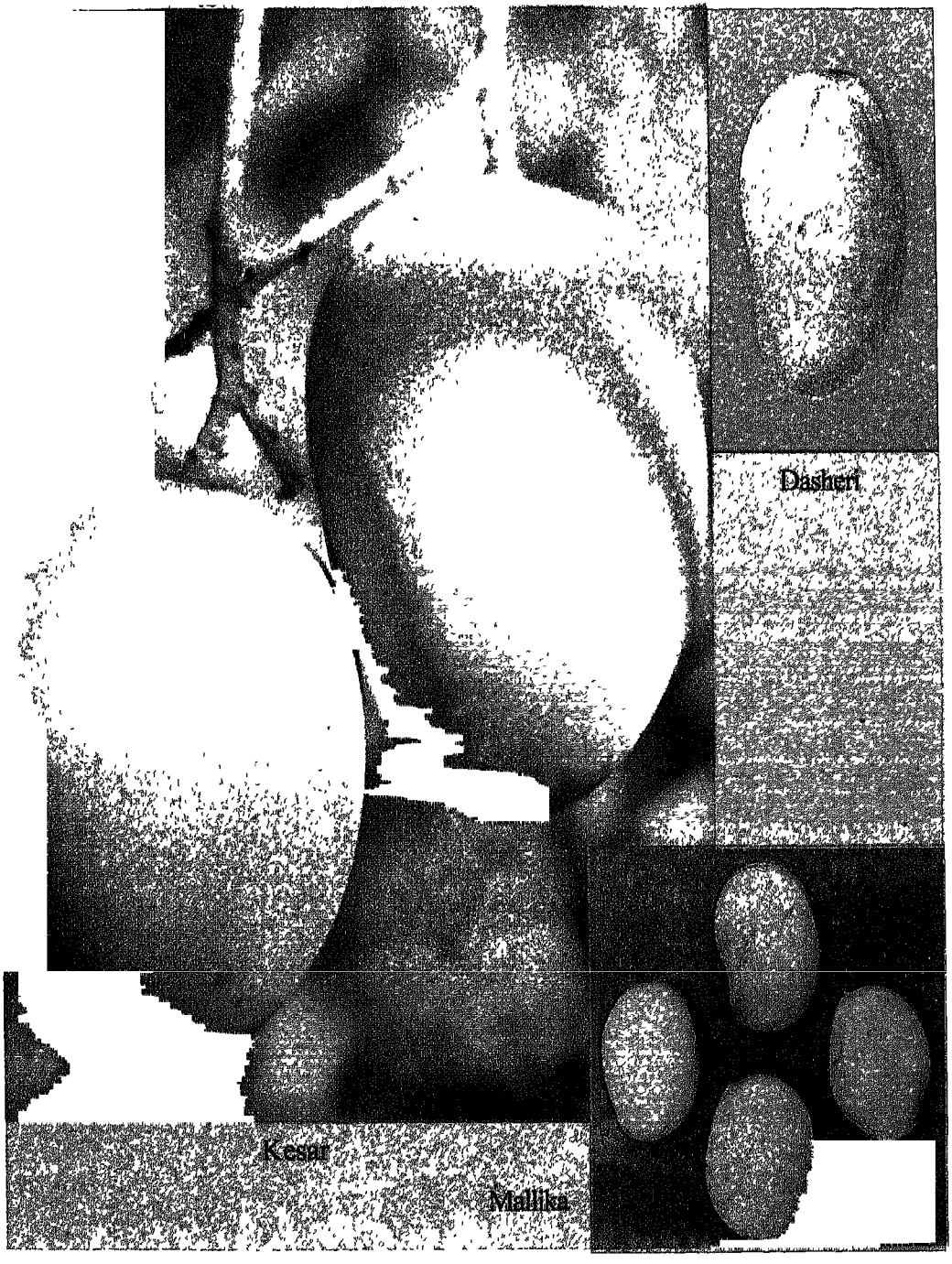
Spongy tissue

This internal physiological disorder, in which the ripe pulp breaks down into soft spongy tissue, is confined mostly to the *Alphonso* variety. Though the exact cause is not known, excessive heat radiation to the fruits from soil is reported to be associated with its incidence, as also the stage of maturity of fruit at harvest, since the incidence has been observed to be negligible in fruits harvested at 3/4th maturity stage. The incidence of spongy tissue can be reduced by straw mulching in inter rows during April and May months, early harvest and proper handling.

QUESTIONS

1. Why is mango called the "King of Fruits" in India?
2. What do you understand by polyembryony? Mention some polyembryonic varieties and explain their utilisation in mango culture.
3. Discuss intercropping and its advantages, with particular reference to mango orchards
4. What are the major insect pests and diseases which attack the mango crop? Discuss in brief their control measures.
5. Explain the following :
   - i Effect of rainfall during flowering in mango
   - ii Precautions for planting a mango graft
   - iii. High density orcharding
6. Write short notes on.
   - i. Spongy tissue
   - ii Malformation
   - iii. Biennial bearing
   - iv Black tip
   - v Monoembryony
   - vi. Fruit drop.

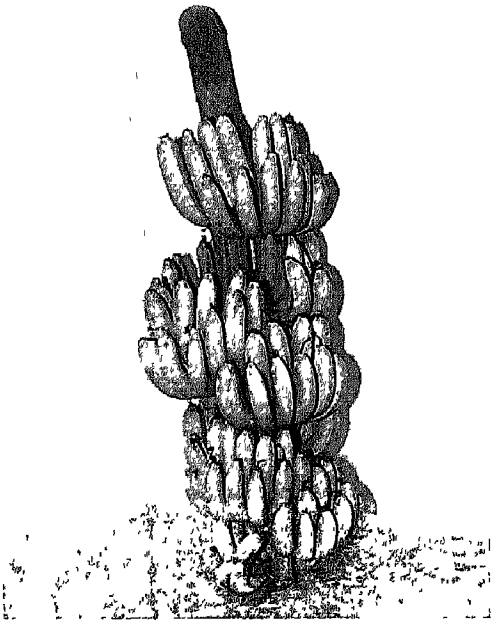
MANGO VARIETIES



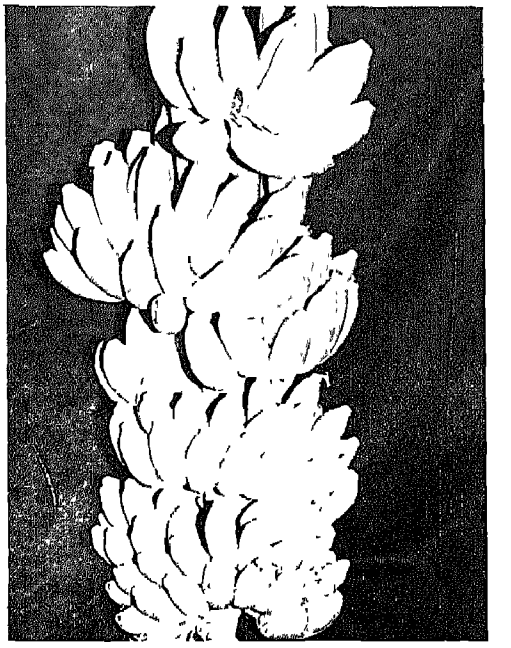
Amrapali

Banganplli

BANANA VARIETIES

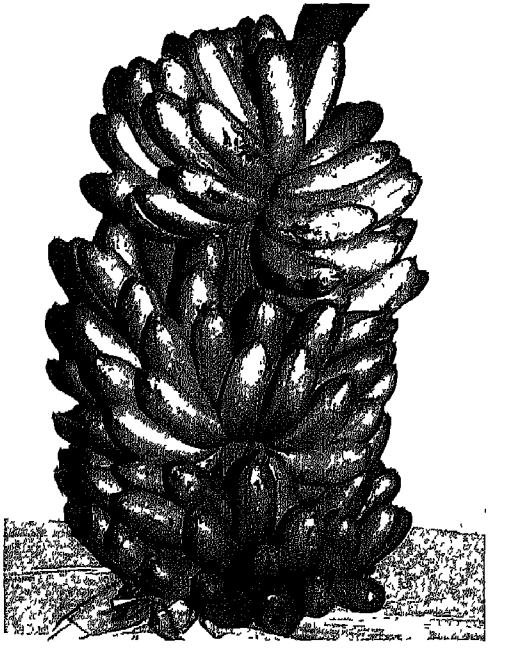


Robusta



Poovan

Nendran



Red Banana

A View of Banana Orchard

BANANA DISEASES

Panama Wilt

Bunchy Top

Chapter 6

Banana

Introduction

Banana (*Musa soo.)* is the second most important fruit crop in India next only to mango Unlike most other fruits, bananas are available almost throughout the year India occupies the second place in banana production in the world. It has been demonstrated that banana provides a more balanced diet than most other fruits and produces more calories per unit area than any other food crop It is a staple food of millions of people the world over and a leading fruit in international trade.

Origin and Distribution

The edible bannana is indigenous to the warm humid parts of Asia, and probably originated somewhere in the mountainous regions of Assam, Mayanmar, Thailand/Indo-China. From here it spread to tropical parts of America, Africa, Australia, the Philippines and Hawaii. Its cultivation has developed most in tropical America Presently, Honduras, Jamaica, Brazil, the Philippines and Mexico are the leading exporters of banana to Europe, the United States of America and Japan.

Botany

Banana belongs to the family Musaceae. There are about 40 species in the genus *Musa*. It is a tree-like herb, perennial but monocarpic and 2-6 m in height. Adventitious roots spread laterally and down, forming a dense surface mat The underground stem (corm, rhizome) has short internodes. The corm's terminal growing point produces leaves in a spiral successsion. Normal leaves consist of a sheath petiole and a blade. The sheaths are necarly circular and tightly packed into a non-woody psuedostem. the petiole is 30-90 cm long and forms a canal The blade emerges from the middle of the stem as a rolled cylinder (cigar) and unfurls slowly. Older leaves are pushed aside until they hang down and their blades shrivel. At any given time, the number of functional leaves remian more or less the same.

Banana is monocarpic and shoots flowers only once and dries after is has fruited Yet the plant is perennial, as the corm's life is perpetuated by suckers

The banana fruit is a berry. It contains many ovules, but no seeds. The fruits develop by means of parthenocarpy, that

Karpoora Chakrakeli (A.P.), *Palayamgodan* (Kerala). This is the foremost commercial variety of Tamil Nadu, Andhra Pradesh and West Bengal. The average bunch weight is about 15 kg. It is immune to 'Panama wilt' disease and fairly resistant to leaf spot. The fruits are small to medium, yellow skinned, firm fleshed with a sub-acid taste. Keeping quality is good. One of the distinguishing characters is the rose pink colour of the outer side of the mid rib.

(ii) *Dwarf Cavendish* Syn. *Basrai* : A leading commercial variety of the whole country. The average bunch has 6-7 hands containing about 125 fruits and weighs about 15 to 25 kg. It is the second most important banana in international trade. This variety is resistant to 'Panama wilt'. The plant is dwarf, fruits are large, curved, skin thick and greenish, and the flesh soft and sweet.

(iii) *Rasabale:* This is a choice table variety and is pricey wherever it is cultivated. Fruits are medium sized with thin skin, ivory yellow colour and sweet with a pleasant aroma. The plants are moderately vigorous, but do not bear as much as *Poovan*. Due to its well developed root system, it can resist wind better than other varieties. Its susceptibility to wilt, easy dropping of ripe fruits from the bunch and formation of hard lumps in the pulp are the main drawbacks. The average bunch is about 12 kg containing 60 to 80 fruits in 5-7 hands. Plants can be identified by the yellowish green stem with brownish blotches and reddish margins of the petiole and leaf sheath.

(iv) *Robusta:* Syn. *Bombay Green* (Maharashtra) *Pedda Pacha Arati* (A.P.).The fruit is longer than that of *Dwarf Cavendish*. It is a semi tall mutant of *Dwarf Cavendish*. The average bunch weight ranges from 25 to 30 kg. The fruits have a better keeping quality than *Dwarf Cavendish*. It is resistant to 'Panama wilt' and has an excellent yield potential.

(v) *Nendran:* This is a dual purpose variety used for cooking as well as for table purposes. Fruits are more than 30 cm long and angular in shape. The bunch weight is 12-15 kg with about 50 fruits. The pulp is sweet. This variety is commonly used for making chips.

(vi) *Madurainga:* This variety is extensively grown for cooking purposes. The plant is tall and bears fruits which are long and angular in shape. A good bunch will consist of about 100 fruits.

Propagation

Banana is propagated vegetatively by means of suckers. Whole or bits of rhizomes of the parent plant or daughter suckers, with at least one sprouting bud, are used. Suckers are of two types and are:

(i) Sword Sucker

This type of sucker has a well developed base and pointed tip with narrow sword-shaped leaf blades in the early stages. Such a sucker produced at the time of flowering of the parent plant, is the best planting material. It may be planted 3 to 5 months after harvest of the bunch.

(ii) Water Sucker

These are small under sized suckers found at the surface with broad leaves. They arise in very old plantation which are overcorowded, shady and not well looked after. This type of sucker is to be avoided.

Preparing a clean sucker by paring the necrotic tissue and coating with mud slurry containing Carbofuran (3 per cent) granules at the time of planting, is recommended. Suckers should be procured from disease and nematode free areas

Tissue culture is the latest technology adopted for mass propagation of disease-free planting materials.

Planting

In the tropics, planting of banana can be done throuout the year. But in general, June-July is by far the most common and best season for planting banana. In winter planting, both growth of the plant and shooting of the bunch are impeded, and a condition known as 'choke a throat' results. *Ddwarf Cavendish* is particularly susceptible to this malady. It is advisable to green manure the land with a leguminous crop for improving soil fertility before planting.

For planting banana, pits of 45 cm cube are dug. The rhizome is placed 22 to 30 cm below the surface of the soil

Spacing

Spacing as given below is recommended for different varieties according to their vigour and habit of growth:

Cultivar	*Spacing mm.*	*No of suckers per ha*
Robusta	2.2x1 8	2500
Dwarf varieties	1 8x1 8	3000
Tall varieties	2 0x2.0	2225

Manures and Fertilisers

The banana is a heavy feeder and responds readily to manuring. The following schedule is recommended for different varieties

Variety	*Nutrient to be supplied (in kg/ha)*		
	N	P_2O_5	K_2O
Dwarf Cavendish	540	325	675
Robusta	405	245	507
Other varieties	400	240	500

Farmyard manure may be applied at the rate of 40 tonnes per hectare i.e., about 20 kg per pit. Fertiliser application has been found to be more effective if applied in split doses. It has been found that fertiliser application should be completed before the initiation of the inflorescence, that is within 5 months time. Generally, the following pattern of split application is followed:

1st Dose - 45-50 days after planting
2nd Dose - 78-80 days after planting
3rd Dose - 115-120 days after planting

Desuckering

The removal of unwanted or surplus suckers can be done by cutting or destroying them without detaching from the mother plant. Studies have shown that removal of suckers, except the one formed at the time of flowering of the mother plant, has given higher crop yield.

The suckers can be effectively suppressed by cutting them to ground level and pouring 2-3 drops of 2,4-D solution in the ratio of 1·16 of 2,4-D and water in the cenral core to kill the growing point of the pseudostem.

Weed Control

Weeding should be done as and when required, and it is necessary to keep the

orchard weed free for an initial three months after planting. Diuron and Gramoxone are the recommended weedicides for banana. Diuron at 2 kg a i./ha is sprayed on the ground surface before the weeds emerge and when the plants are 1-2 months old. Irrigation is given within 3 days of spraying the herbicide, and then at usual intervals. A spray of Gramoxone at 1.5 litres in 1,200 litres of water is given after six months of Diuron spray.

Interculture

(a) Earthing Up

Earthing up should be done during the rainy season to provide drainage and to avoid water-logging at the base During summer and winter the plants could be in furrows for efficient irrigaion.

(b) Propping

Where wind is a problem, the psuedostem requires to be propped up with bamboos, especially at the time of bunch emergence.

(c) Wrapping

Covering of bunches with thick paper, gunny or blue polythene sleeves protects the fruits from sunburn, hot wind and dust and improves their appearance and even advances maturity.

(d) Removal of Male Bud and Floral Remnants

The male bud is removed after the fruit formation is complete in some varieties as this operation is said to promote fruit development.

Irrigation

Banana requires copious irrigaion. The irrigation needs vary considerably, depending upon the topography, soil, climate, type of culture and economic factors. The soil in banana plantation should not be allowed to dry completely In most inland areas, 40-50 irrigations are required from the time of planting to harvest. On an average, irrigation once in 4-5 days is required during the warmer months in Februay to May. Deep irrigation channels are formed for every two rows, and cross channels of the same depth with 4-6 plants in each bed. About 60-80 per cent of the available soil moisture may be considered as optimum for banana. Drip irrigation method is slowly becoming popular.

Plant Protection

(a) Major Insects and Their Control

i. Rhizome Weevil (*Cosmopolites sordidus*)

The is one of the most destructive inseets which cause heavy damage to banana The cultivar *Nendran* is highly susceptible to this insect. Severely damaged corms show several feeding tunnels and appear as a blackened mass of rotten tissues.

Application of Phorate granules at 10 g/plant has been found to be the best for effective control of this insect.

ii. Banana Aphid (*Pentalonia nigronervosa*)

This being a vector of 'Bunchy Top' virus disease plays an important role in the

introduction and spread the disease The vector can be controlled by spraying Rogor or Malathion or Metasystox at the rate of 2 ml/l of water whenever the infestation is seen

iii. Nematodes

Burrowing nematodes (*Radophilus similis)*are widely distributed in banana growing areas. The first symptoms of the disease are small dark spots on the roots. Affected plants do not respond to fertilisers, irrigation or cultural practices.

Before planting, peeling the corms free of all lesions and dipping them in a nematicide solution, or covering them with granular nematicides like Carbofuran at the rate of 40 g/sucker or by coating them with mud slurry covering nematades is effective

(b) Major Diseases and Their Control

1 Sigatoka Leaf Spot *(Cercospora musea)* Perfect Stage *Mycosphaerella musicola)*

The first symptom of infection is the presence of light yellowish spots on the leaves. Spraying with Dithane M-45 at 0 25 per cent or Bordeaux mixture at 1% gives good control of the disease

ii. Cigar End Rot

This disese is caused by *Verticillium theobromae.* A black necrosis spreads from the perianth to the tip of immature fingers. The corrugated necrotic tissues become covered with fungus and resemble the grayish ash of a cigar end

This disease can be controlled by spraying with 0.05 per cent Benlate.

iii. Anthracnose

This disease is caused by *Gloeosporium musarum.* Pale grey spots appear on the fruits affected by this disease. Anthracnose can be controlled by spraying Dithane Z-78 (0.2 per cent), or Dithane M-45 (0.3 per cent).

iv. Panama wilt

Panama wilt is caused by a soil borne fungus *Fusarium oxysporum* which enters the plant, through the roots and injured rhizomes. *Robusta* and *Dswarf Cavendish* varieties are relatively resistant.

It is better to avoid planting in soils infested with this fungus and to grow resistant varieties.

v. Bunchy top

Bunchy top is the most serious virus disease affecting banana plantations. The aphid (*Pentalonia nigronervosa)* is the vector. *Dwarf Cavendish* is highly susceptible to this disease. Obtaining disease free planting material and eradication of disease infected plants from the field are useful in minimising the incidence of the disease. It can be kept under control by spraying with insecticides and controlling the aphid vector.

Handling Harvesting, Maturity Standards and Handling

Bananas are harvested at different stages of maturity depending on the distance of haulage and time of consumption and it may further vary from variety to variety. The usual practice is to harvest the bunches when the fingers are three-

quarters filled. Bunches for distant markets are harvested about 10-15 days earlier than bunches which are meant for the local market. Visual observation, number of days taken from emergence and pulp to skin ratio are some of the various methods to determine maturity. Rounding of edges on fingers is the best indication of maturity and 25 per cent rounding is recommended for harvesting for most commercial varieties.

Bunches are normally harvested with the stalk After auction in the local market, they are graded according to finger size and number of hands. Bunches are wrapped in banana leaves and sent to distant markets. Packing in boxes is not common in our country, only 5 per cent of the produce is packed in this way due to prohibitive cost of packing material. Thus bulk of banana bunches are transported unpacked either in railway wagons or lorries Stacking of bunches after removal of main stalk and unwanted lower hands is done in such a way that the fingers are not damaged.

In many places bunches are wrapped with banana leaves. But large scale transportation is by train which involves tight packing of bunches in railway wagons.

Yield

Yield takes about 12 to 15 months after planting for dwarf varieties, and 15 to 18 months for tall varieties to be ready for the harvest.

Dwarf Cavendish produces 30-40 tonnes of fruit per hectare, while in *Robusta* a yield of 40-50 tonnes can easily be obtained. In other varieties it may range from 20 to 30 tonnes per hectare depending upon the variety. However, the national average is around 17 tonnes per hectare.

Studies have indicated that yield per unit area in *Robusta* variety of banana can be increased with increased plant density.

Storage, Transport and Ripening

Banana can be stored at about 13° C and a relative humidity of 85/95 per cent for three weeks and is ripened in a week 16.5 - 21°C. Banana fruits become blackened at lower temperatures and hence should not be placed in a refrigerator. Internally the banana is carried either by rail or by road in unrefrigerated carriages. But for overseas trades, refrigerated ships with cool air circulation at about 11-13.5° C are used. Storage life can be increased by keeping the fruits in a high concentration of carbondioxide and low concentration of oxygen. Dipping of fruits at 200 ppm TBZ is also recommended as a post harbvest treatment.

The banana fruit harvested at three fourths maturity can keep well at room temperatures for 5 to 7 days depending upon the season and the weather. The storage life of banana can be prolonged by using sealed polythene bags containing ethylene and an absorbent like potassium permanganate Calcium carbide and ethrel are used to hasten ripening.

Bananas are not usually allowed to ripen on the plant and smoking is the common method to induce ripening. Smoking is done for 18-24 hours in summer and 48 hours in winter with straw, leaves and cowdung in a closed chamber with bunches arranged in a heap. After taking out the bunches from the chamber they are placed in a well

ventilated room for the development of colour before marketing.

Marketing

A large volume of banana produced in the country is consumed mostly in the domestic market. Banana produced in one region is transported to other regions by rail or road and distributed to different retail sellers (Fig-6 1)

Fruit trade in general is in the hands of private merchants despite existence of many active cooperative societies and federations. Many times, the fruit passes through two or three hands before reaching the consumers The trader is also responsible for grading and packaging of fruits

Growers→ Growers Cooperative Societies
↓
Traders
↓
Commission agents
↓
Retail sellers
↓
Consumers

Fig. 6.1 Marketing Flow chart

QUESTIONS

1 Banana is a complete food. Justify the statement in the light of its composition and uses.
2 Give the origin, distribution and climatic requirements of banana.
3. List the maturity indices of banana and discuss its post harvest handling.
4 What are the problems in banana production? Give possible solutions.
5 Write a note on the nutrional and water requirements of banana.
6 Wirte short note on·
   i Desuckering ii . Propping
   iii Panama wilt iv. Bunchy top
7 Differentiate between the following·
   i Cooking and dessert bananas
   ii. Water and sword suckers

CHAPTER 7

Citrus Fruits

Introduction

Citrus fruits in India hold a position of pride, ranking third after mango and banana. Citrus fruits are delicious and rich in vitamin C and have great nutritive value in the human diet. Besides, they provide other nutrients like carbohydrates, proteins and minerals. Among the various citrus fruis, sweet orgamges and mamdarins are grown in a larger area followed by limes and lemons

Origin and Distribution

Most of the species of genus *citrus* are believed to be native to the sub-tropical and tropical regions of Southeast Asia, particularly India, China and the region between these two countries, from where they have spread to other parts of the world

Citriculture in India is believed to be second only to China, and many species of citrus, particularly mandarins, limes, lemons and others are believed to be native to India, originating in the northern Himalayas and Northeastern regions of India (Assam). These species include *Citrus ichargensis, C. indica, C. latipes, C macroptera, C Jambhiri, C. limaonia* (Rangpur Lime), *C.assamensis, C Karna, C. limettioides, C aurantium, C megaloxycarpa, C.* aurantifolia and *C. reticulate* (Khasi mandarins). The other citrus fruits, such as sweet oranges, some mandarins, sour limes and pummelos are introductions from outside

Nutritive Value and Uses

The chemical composition of different citrus fruis vary greatly from one group to the other. In the sweet group (sweet oranges, mandarin and others), the edible part of the fruit has the principal constituents like sugars (glucose and sucrose) and acids (citric acid and malic acid) The acid group (lime, lemons, citron and others) primarily have the acid in the juice. Besides these, citrus fruits contain a considerable amount of vitamin K. which keeps the small blood vessels in the body in a healthy condition and help in the assimilation of vitamins. Therefore they are more efficient to relieve

the deficiency of vitamin C than tablets of vitamin C. In the sweet group, the TSS ranges between 8-12 per cent titratable acidity 0 5 to 1 5 per cent and vitamin C 2 5 to 8 0 mg/100 g of juice The sour group contains titratable acids as high as 5-6 per cent.

The rind of citrus fruits contain pectin, essential oils and certain glucosidess.

Citrus fruits, apart from being used as fresh dessert fruits, are processed into marmalades, juices, squashes and pickles The flowers, leaf and rind are used to obtain essential oils for use in medicines, perfumes and as flavouring agents. The major industrial products of citrus fruits are citric acid and pectin.

Area and Production

The annual production of total citrus fruits is estimated at 54.43 mt, of which sweet oranges contribute 37.54 mt,mandarins 7.04 mt. limes and lemons 5 40 mt, constituting 72, 14 and 10 per cent, respectively of the total world production. The total production in India is estimated at 15.80 lakh tonnes of which 5 10, 7 01 and 3 69 lakh tonnes are contributed by sweet oranges, mandarins and limes and lemons, respectively, Citriculture in India is only about a centry old. Various citrus species are cultivated in India extending from subtropcal to tropical climate range Among these, sweet orange in Rajasthan, Punjab, Haryana, Maharashtra and Andhra Pradesh mandarins in Assam, Coorg (Karnataka), Nagpur (Maharashtra) and Kerala and acid lime in Maharashtra, Andhra Pradesh, Tamil Nadu, and Gujarat are commonly grown. Besides these, lemon, grapefruit and pummelo are also produced but on a small scale

Climate

All the citrus fruits grow well under tropical conditions. They can withstand occasional frost conditions, although one cannot be sure of obtaining good results in cooler regions. Each species differs in its tolerance or resistance to frost and other conditions Limes and lemons thrive in a warm and moderately humid climate They cannot withstand low temperature Areas free from strong winds are ideal Limes thrive well in a dry climate while mandarins grow well in warm humid climate Sweet oranges need dry and subtropical climate with irrigation support for better quality development.

A well distributed rainfall between 125-185 cm is considered adequate for rain fed cropping of citrus fruits. Irrigation is necessary. In areas with an annual rainfall of less than 50 cm Young trees are more susceptible to climatic fluctuations as compared to older trees.

Soils

Sweet oranges, mandarins, limes, lemons and other citrus fruits are adaptive to a variety of soil types, but sandy loams and clay loams are considered the best. Since citrus plants have deep tap root system, the depth of soil should be at least 1.5 to 2.0 m and the water table below 1 0 to 1 5 m. They tolerate a wide range of soil pH between 4 5 to 8.5 but the optimum pH is around 6.5-7.0. Citrus trees are highly susceptible to soil salinity and one has therefore to be very careful in choosing the soil for growing citrus fruits. Any soil with electrical conductivity

of more than 0.5 mmhos/cm should be rejected unless one has a rootstock tolerant to salinity

Citrus fruits are highly susceptible to waterlogged conditions and bad drainage, hence well drained soils such as sandy loams or medium clay loams should be preferred. Soils with hard pans, excess of free lime and low lying situations should be avoided for planting citrus fruits.

Varieties

There are a large number of varieties in sweet oranges and mandarins.

Sweet Oranges

Mosambi, Sathgudi, Blood Red Malta, Washington Navel, *Valencia, Pineapple, Hamlin, Jaffa* and *Bibille seedless.*

Mandarins

Coorg, Nagpur, Khasi and *Kinnow*

Lime

Kagzi

Propagation

Although some growers still use seedlings, vegetatively propagated material should be preferred. The most common method of vegetative propagation adopted in citrus is by shield and Forkert method of budding. However, in acid lime nuclear seedlings are preferred being virus free and vigorous

Seedlings raised from selected rootstocks are ready for budding in 15-24 months, depending upon the rootstock species. The suitable season for budding is between July-October, depending upon the local conditions. Periods of heavy monsoon and severe winter should be avoided, because the bud take of will be poor in such weather conditions

Raising Seedligs for Rootstocks

A few selected rootstocks are used for budding, and the choice of the rootstock depends upon the scion used and other local conditions such as soils and incidence of fungal and viral diseases. Some of the most commonly used and recommended rootstocks are: Rough lemon (*C.Jambhiri*), Cleopatra mandarin (*C.reshni*). Rangapur lime (*C. limonia*), Trifoliate orange (*Poncirus trigoliata*), and citranges (Troyer and Carrizo)

Seeds are extracted from fruits of selected healthy and virus free mother trees, and sown in light, disease free and well drained soil. Since the nursery beds (primary or secondary) may not be free from soil pathogens, it is necessary that they are pretreated with a suitable fungicide to avoid soil-borne fungal diseases. The seedlings with 4-6 leaves in the primary seedbed are transplanted in the secondary beds, giving a spacing of 20-30 cm between rows and plants. Seedlings of uniform stand in the secondary nursery beds are chosen for budding to eliminate gametic seedlings, with the scion wood collected from selected mother trees. The optimum thickness of the rootstock seedling for budding may be that of a pencil and the seedling should have a straight stem

(i) Budding

For raising the right type of budings, the important points to be considered are (a) choice of nucellar seedlings as rootstocks while using polyembryonic species, (b) collection of virus/disease free bud wood from the virus indexed

mother trees, (c) selection of the right type of bud wood, and (d) use of vegetatively propagated material for rootstock purposes in species which are not polyembryonic The budding would be ready for transplanting in the main field within 9-12 months after budding

(ii) Layering and Cuttings

These are practised only on a limited scale in lemons, sweet lime and citron. The plants developed from layers of cuttings are generally shallow rooted and hence not preferred for large scale planting.

Planting

Citrus plants are usually planted before the onset of the monsoon in pits of 90 cm cube, spread at 6 m apart. Pits are filled with top-soil and compost, allowing 1-2 months for weathering and settling of the filled up soil. Seedlings or buddlings are transplanted in the centre of the pit.

The plants are planted either bare rooted or with a ball of earth. If bare rooted they may be planted during monsoon for better establishment, but plants with a ball of earth may be transplanted after the monsoon is over Depending on the environment and soil conditions, the transplants are required to be irrigated at regular intervals. Immediately after transplanting, staking should be done to avoid damage by wind

Interculture

Citrus orchards are raised either under rain fed situations in certain regions (like Coorg District (Karnataka) or under irrigation with basins of 2-3 m in diameter, depending on the age of plants. The only intercultural operation carried out in citrus plantations is weeding in the basins at regular intervals, at least twice a year The soil around the plant is scuffled once or twice to check weeds.

The interspace between the plants is also intercultured with light hoeing by light digging to control weeds and to loosen the soil for better aeration and absorption of rain water Since major quantity of active absorbing roots (fibrous roots) are within 15-30 cm from the soil surface, frequent interculturing or deep digging should be avoided.

Training and Pruning

Training of the plants is essential in the initial years The seedlings are trained to a single stem by removing lateral branches. A grown up tree should have a clear stem of at least one metre from the ground level to avoid branches coming in contact with the ground and getting infected with soil borne diseases, and to facilitate cultural operations under the tree canopy.

Pruning is equally important but restricted to the removal of water sprouts and dried or diseased twigs or branches. This is normally done during the summer or nonflush period and after harvest. The pruning operation provides a youghful appearance to the plants and promotes new growth in the season Severe pruing is advocted for complete removal of dried or diseased branches.

Intercropping

Intercropping in citrus is carried out in a limited way only in the early stages of growth till bearing. Growing of legumminous crops like cowpea, horse gram and beans is desirable Short-duration vegetables can also be grown.

As the selection of intercrops is very important, the following points should be kept in mind while selecting them
(a) They should not exhaust the soil by depriving or competing with the citrus plants for soil nutrients and moistrue
(b) They should not be such as would need intercultural operations or irrigation that are not required by the citrus plants.
(c) Undesirable intercrops may affect the citrus plants through exhaustion of soil nutirents, deterioration in the soil's physical properties, root injury due to deep soil working, shading the plains and acting as alternate hosts for certain diseases and pests.
(d) They should be of short durfation shallow rooted and with a good canopy to cover the soil surface to check soil erosion.
(e) A properly chosen intercrop whether a legume, vegetable or fodder, should be profitable to the grower.

Manures and Fertilisers

Citrus fruits are generally considered to be heavy feeders In addition to the usual requirements of major elements they need to have a steady and adequate supply of micro nutrients like Zn, Mn, Cu, Fe, Boron and others They are highly sensitive to deficiency of these minor elements The major elements N, Ca and Mg are often deficient especially in areas receiving heavy rainfall due to leaching of some of these elements. The deficiencies are often influenced by the soil type and level of precipitation. Sandy soils are generally less fertile than clayey soils. Soils of humid regions are normally highly leached and the avaliability of nutrients in such soils is poor They are acidic and often deficient in N,P,B, Fe, Zn, Mn, Cu and Mo. On the other hand, the alkaline soils of arid regions do not get leached and under such situations, carbonates, sulphates, cholorides of Na, Ca, K, Mg accumulate which need to be leached out. In such soils N,P,K and Ca are well supplied, but elements like Zn, Mn, Fe and Cu get fixed, though they are adequately present in the soil

The correction of the deficiencies in many of these minor elements is generally done through foliar sprays of these elements and in many cases, it is easily done However, the foliar sprays have not helped much in respect of Fe (because of its immobible nature) unlike in the case of Zn, Mn, Cu and others. In case of soil aplication, it always gets fixed and, therefore, application of Fe in its "chelated" form helps Though favourable results have been observed by even soil application of most of these elements, they are best given as foliar sprays

The citrus growers have to choose the best method, depending on the soil and leaf status of these elements, and include the requirements in the regular spray and soil application schedules. The deficiency of Zn, Cu, Mn, is generally noted in citrus orchards Usually, they are applied in their salt forms as zinc sulphate, copper sulphate, ferrous sulphate, manganese sulphate, boric acid and ammaonium molybdate. The dosage may usually be from 0.5 to 1.0 per cent depending upon the seventy of deficiency in case of alll these elements except B and Mo. Boron may be given as sodium borate or boric acid at 0.25 to 1.0 kg in 250 litres of water and molybdenum as ammonium molybdate at 30 g in 250 litres of water

It is advisable to include at least Zn and Mn, Fe or Cu, dpending upon their status, in the spray schedules to be

given twice a year on the fast growing new flushes. In the case of major elements, N is often deficient and it can be met by foiar sprays of urea at 0.5 to 1 0 per cent and some of the minor elements can be combined and given. The spray solutions have to be neutralized with spray of lime (calcium oxide) to avoid scorching, except in the case of B and Mo, where no addition of lime is required. It is necessary that the pH of the final spray solution of all these elements is best maintained at 6.5 to 7.0 for greater efficiency.

NPK Doses for Citrus

The level of application varies due to many factors like variety, age of tree, general health, stage of growth, yield level, fertility and physical condition of the soil, etc. However, with the available information on fertiliser doses, the following doses could be recommended. Necessary alterations based on soil and plant tissue tests and other conditions may be made to suit the local requirements.

Fertiliser Application Schedule

1. Limes and Lemons

(i) Farmyard Manure or Compost

Time at Planing	*Quantity/pit (kg)*
Before planting	15
After planting	
After 1 year	5
After 2 years	10
After 3 years	15
After 4 years	20
After 5 years	30

(ii) Fertilisers

Nutrients	*Per plant (g)*	*Per ha (kg)*
N	500	241 5
P	300	144.9
K	500	241 5

2. Mandarins and Sweet Oranges

(i) Farmyard Manure

Time of Planting	*Quantity/Plant (kg)*
At the time of planting	50
After first year	Nil
After second year	10
After third year	15
After fourth year	20
After fifth year	30
After sixth year and onwards	40

(ii) Fertilisers

Year	*Nutrient*	*Per plant (g)*	*Per hectare (kg)*
First	N	35	9 45
	P	135	36 45
	K	13	3.45
Second	N	120	32 40
	P	120	32 40
	K	73	21 05
Third	N	270	72 90
	P	270	72 90
	K	180	48.60
Fourth	N	400	108.00
	P	250	67 50
	K	400	108 00
Fifth	N	550	148.50
	P	370	99.90
	K	550	148 50
Sixth and onwards	N	550	148 50
	P	370	99 90
	K	550	148 50

Sixth year and onwards, in addition to the above listed dose, spray of 1.5 kg zinc sulphate, 1 kg magnesium sulphate, 500 g magnesium nitrate, and 1 5 kg lime in 450 litres of water during May and June is recommended. The trees may be sprayed again with 1.5 kg zinc sulphate, 750 g magnesium sulphate 500 g magnesium nitrate and 500 g urea in 450 litres of water during September.

The notable point in citrus fertilisation programme is the split application, since citrus plants have an inbuilt capacity to flush and flower more than 2 or 3 times in a year, depending on soil moisture status and other environmental conditions, and consequently yield in fruits in varying degrees each time To meet the continued needs for vegetative growth and fruitng, split applications have been found to be very useful, at least 2-3 times in a years Such application minimise the losses as compared to one time application.

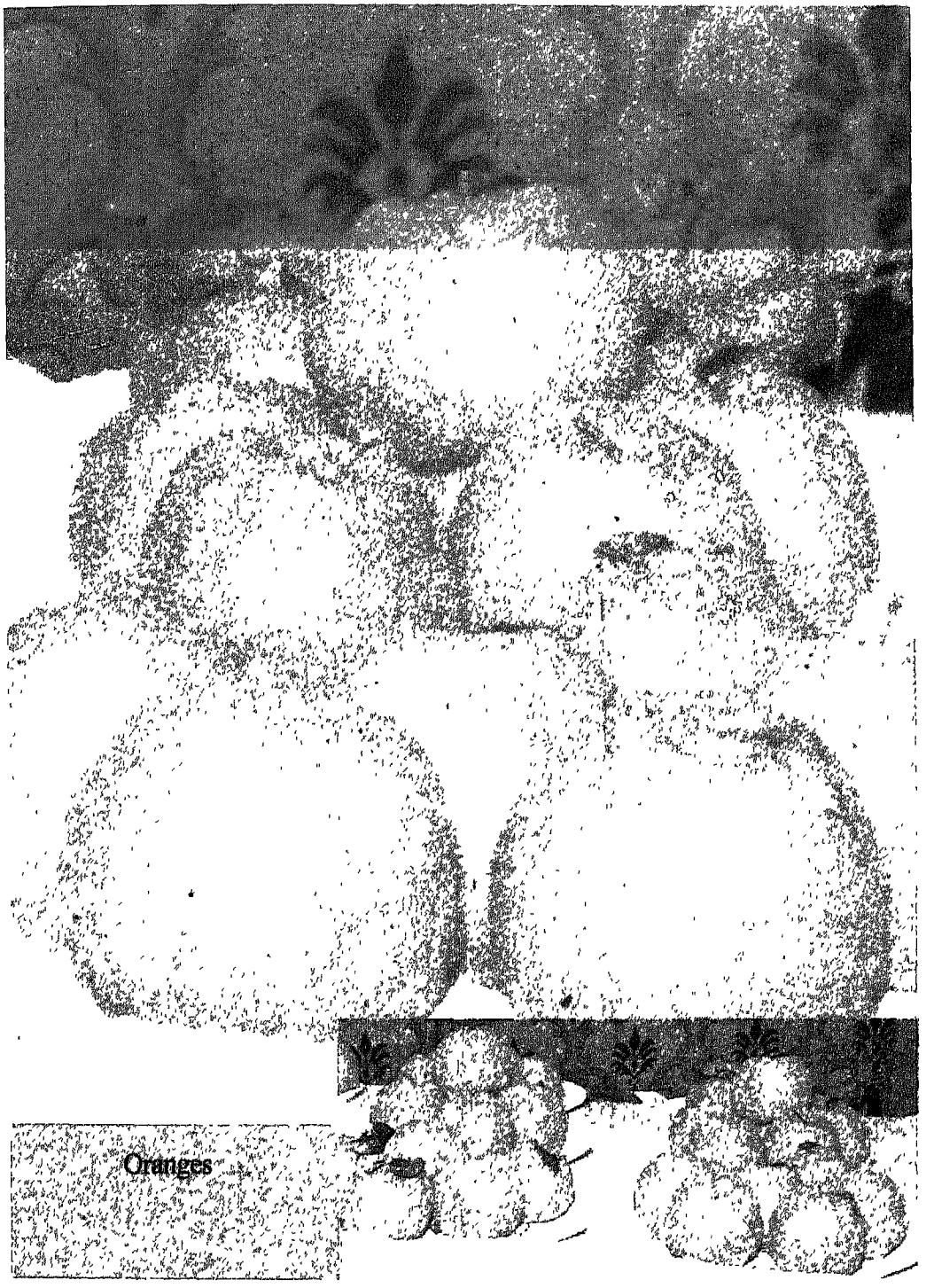
Irrigation

Citrus trees may be grown under rain fed and irrigated situations if the annual rainfall is between 1,500-2,000 mm and is well distributed, the plants could be grown as rain fed However, if the amount of rainfall is less than 750 mm, the orchard can be successful only with assured irrigation The irrigation should be optimum for maintaining a good root environment. Excess water exerts more adverse effect on root growth than its deficieny. The roots rot and become prone to many fungal diseases. The problem of citrus decline is found to be closely associated with the degeneration of roots. Best root growth is maintained at adequate levels of irrigation but never under deficit or excess level The total requirement of water may be about 1,250 mm per year and this may be partly met by rains and the rest by irrigaion. Depending on the rainfall, the time and frequency of irrigation have to be adjusted. In general, young plants may be irrigated once in 3-4 days and the older ones in 7-10 days. The interval may be once a week in summer and 10 days in winter. It is advisable to put plantation under drip for better water use efficiency and results.

Flowering and Fruiting

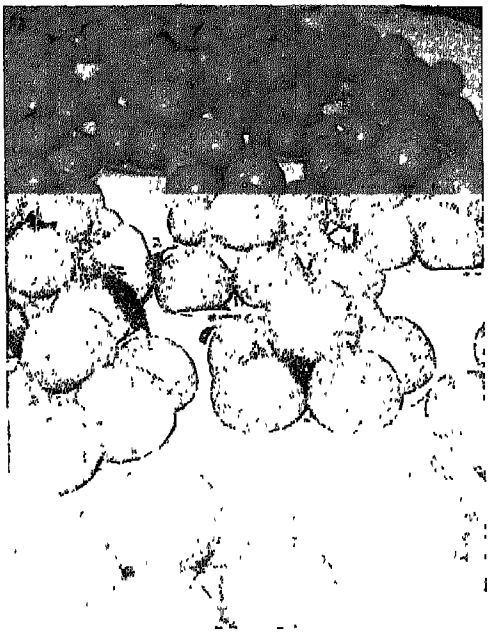
In most of the citrus species and varieties, flowering and fruiting generally occurs twice in a year although they have the capacity to flower and fruit more than twice if favourable soil moisture and temperature conditions are available. The sour group —lime, lemons, citron, etc flower almost throught the year under favourable conditions. The flowering is, however, primarily controlled by temperature conditions. The pattern of flowering and fruiting in North India and South India differ distinctly. In the North, with the onset of spring and rising temperatures, the citrus trees bloom during February-March, while under South Indian conditions where there is no distinct winter, the flowering period is extended and also not very well marked. Under such situations a third crop is also not uncommon.

The flowering and fruiting in citrus plants can be regulated to suit the needs. The earlier method was to withhold irrigation and force flowering whenever desired but this practice has been discontinued now, since it was found to be detrimental to the trees, eventaually

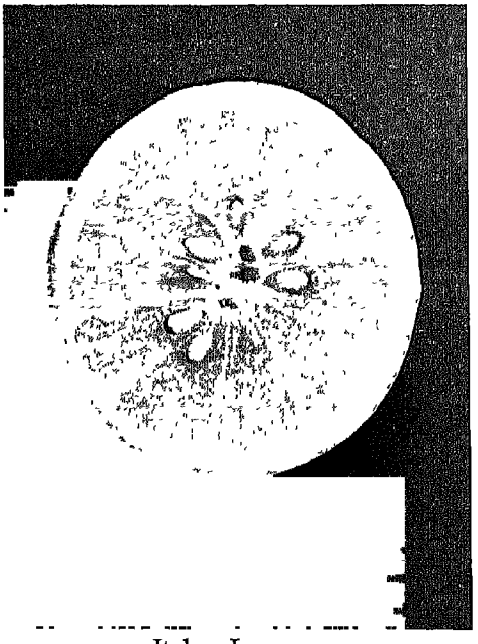

Oranges

CITRUS FRUITS VARIETIES

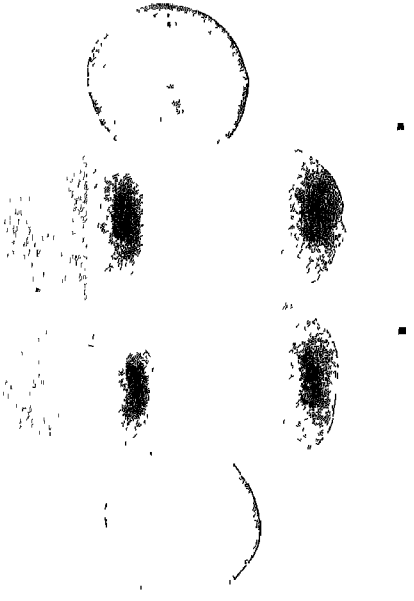
Nagpur Mandarins



Kinnow



Italian Lemon



Kagzi lime

leading to citrus decline. The latest approach is to achieve this objeective by spraying certain growth regulators or chemicals which either increase flowering or, at higher concentrations, debloom or thin out the flowers for increase of flowering in the desirable season Growth retardants like CCC at 1,000 ppm or succinic acid and 2.2-dimethylydrazide (SADH) at 2,500 ppm are used for increasing flowering in lemons. Auxins like NNA are either used for induction of flowering or flower/fruit thinning at appropriate concentrations.

Fruit Set

Poor fruit set has been one of the reasons for low yield in citrus. Fruit set can be improved by spray of certain auxins. A spray of 2,4-D at 10-15 ppm in various citrus spp has been found to increase the fruit set.

Fruit Drop

Fruit drop is one of the serious production problems in citrus. Dropping of fruits at different stages of their growth takes place and generally three major drops (June drop, pre harvest drop, physiological drop/pathological drop) are recognised in various citrus fruits. The drop may be severe in some and moderate in others.

The dropping occurs either due to a natural phenomenon for getting adjusted with the crop load in relation to vigour of the tree or due to various other factors like desiccating wind, low atmospheric humidity, high temperature, stress for soil moisture and incidence of diseases and pests.

The fruit drop in June when fruits are of peanut size is considered serious. This is usually caused by high temperatures and low humidity The second drop is 'pre-harvest drop' which occurs just before the harvest of fruits and is a severe problem in sweet oranges like *Mosambi* and *Blood Red Malta*. Physiological and pathological factors have been found to be associated with 'pre-harvest drop'.

Control Measures

Auxins are effective in controlling fruit drops. Two sprays of 2,4-D at 10 ppm in August and October minimise the pre-harvest drop to a considerable extent. Drop associated with pathogens is controlled by addition of any suitable fungicide like Bordeaux mixture to 2,4-D solution.

Plant Protection

(a) Major Pests and Their Control

A number of pests are found to affect citrus plants. Some of the important ones are: Stem borer (*Chelidonium cinetum*), leaf minor (*Phyllocnistis citrella*), citrus psylla (*Diaphorina citri*), aphids (*Aphis spp.*), mealy bugs (*Pseudococcus species*), citrus/lemon butterfly (*Papilio sp.*), fruit-flies (*Dacus spp.*), mites and fruit sucking moths. However, in comparison to diseases, they are not serious and can be easily controlled by the locally available insecticides.

(b) Major Diseases and their Control

The three major groups of diseases which attack citrus crops are: fungal, bacterial and viral of which fungal and viral diseases are more important as they cause serious damage.

1. Fungal Diseases

The important ones are: gummosis, root rot, crown rot, ganoderma root rot, dry root rot, and powdery mildew.

(i) Gummosis and Rots

Gummosis and other rots are of a serious nature and often detrimental to trees. These rots are casued generally by *Phytophthora species* of which *P.Parasitica, P.citrophthora* and *P. palmivora* are important.

In case of gummosis, the collar region of the tree or even the lower branches show oozing of gum and longitudinal splitting and shredding of the bark.

Root rot may be wet rot or dry rot, but in case of ganoderma root rot, the fruiting body of the casual fungus apears at the advanced stage of infection.

Preventive measures are always better since the control of these disorders is difficult after their apppearance. As precautionary measures, low lying situations and stagnation of water around the tree trunk should be voided and good drainage provided The trunk up to 60 cm from the ground level should be painted with Bordeaux mixture every year. High budding and use of resistant rootstocks are some other preventive measures. As a control measure, the affected area of the stem of branch should be scraped and Bordeaux paste applied.

(ii) Powdery Mildew (Oidium tingitanium)

Powdery mildew is a common disease, often occurring with the new flush. A whitish powdery growth developes on the young leaves and twigs and leads to defoliation and dieback of twigs and dropping of fruits.

Dusting of sulphur powder (200-250 mesh) or spraying wettable sulphur is effective to control the disease.

(iii) Scab (*Elsinoe Fawcetti*)

Scab causes corky lesions on fruits, leaves and young twigs. The leaves become distorted and wrinkled and the affected fruits become hard and drop prematurely. It is controlled by pruning the affected parts and spraying copper fungicide at regular intervals.

2. Bacterial Diseases

(i) Canker

The only important disease is citrus canker (*Xanthomonas citri*) often confused with scab. It is widespread and serious in limes. It affects both seedlings and grown up trees. The leaves, twigs, fruits and even thorns are infected. Minute water soaked roundish spots appear and gradually turn brownish and become corky. A yellow-brown halo also surrounds the lesion.

Pruing and burning the affected parts before monsoon and spraying 1 per cent Bordeaux mixture of Streptomycin (500 pmm) at regular intervals is recommended. Control of the incidence of leaf minor, a pre-disposing factor, is also advisable.

3. Virus Diseases

A number of virus diesase occur of which Tristeza and Greening are the important ones.

(i) Tristeza

Tristeza is widely present in India and

affects almost all the varieties of citrus, although some of them are highly tolerant. The virus appears when rootstocks susceptible to it, such as sour orange, lime and others, are used in budding with different scion varieties.

The affected trees generally exhibit stem pitting and vein clearing which are the two important symptoms. In the affected tree, when a strip of bark is pulled open, pitting on the inner side of the bark and pegs on the stem corresponding to the pts are seen. The affected leaves when held against the light, show clearing of veins. The leaves show interveinal chlorosis resembling zinc deficiency, internodes become short, trees become stunted, blooming is heavy, leaves shed and dieback of twigs takes place, gradually leading to the dealth of affected trees.

This disease is transmitted by vectors (aphids) from the diseased to the healthy parts of the plant by transfering the plant sap. The different vectors should be controlled by regular insecticidal sprays. Use of tolerant root stocks like Trifoliate orange. Rangapur lime, Cleopatra mandarin is another method of control

(ii) Greening

Greening is widespread in India and considered next to Tristeza in importance. The causal organism is still not clearly known, though believed to be due to mycoplasma and not virus. The symptoms by and large resemble zine deficiency. The veins become yellow as in zine deficiency. Fruits become small, lopsided with green islands, and fall off.

Since the disease spreads through infected bud wood and the vector citrus psylla (*Diaphorina citri*), the vector has to be controlled, and disease free scion material has to be used. This does affect the plants irrespective of the rootstock used and hence choice of the rootstock is not of advantage.

Maturity and Harvesting

Most citrus species may generally be expected to commence bearing from the third year after planting, except in the case of seedlings, although economic bearing would start only from the fifth year. Fruits are in their prime quality when sugar and acid contents show a balanced blend, or when sugar content is at its best. They ripen in six to seven months after fruit set depending upon the species and the variety and in some cases it may be even later. Since the fruits mature better on the tree, picking should be as late as possible. Citrus fruits belong to the non climactric group of fruits and will not ripen after harvest. Therefore, they have to ripen on the tree itself to develop into quality fruits. The quality of fruit juice attains its best at full maturity, remains constant for some time and then deteriorates. Harvesting time depends on varieties. Early variety cannot be left on the tree very long without loss of quality. While, the late varieties usually improve with delayed harvest, undue delay will have adverse effects both on the fruit quality and on tree health. Fruits for export are generally picked before full maturity fixed for various citrus fruits. For instance, in the case of mandarins, the fruits should contain a minimum of 45 per cent juice, 15 per cent TSS, acidity not more than 0.75 per cent and ascorbic acid 46-60 mg/100 ml of its juice. The TSS/acid

ratio may be between 13-15. Such maturity standards are strictly followed in advanced citrus growing countries of the world.

Harvesting has to be done with utmost care avoiding any injuries to the fruits. Safe arrival of fruit at their final destination depends on how they are handled from the time they are picked from the tree until they are presented for sales at the retail counter. It is, therefore necessary to see that apart from harvesting at right maturity they are also picked carefully and handled delicately. In India, the methods of harvest are still crude, The fruits are harvested either by contract labour or by the owner himself. The common practice of harvesting the fruits still continues to be the traditional method of 'twist and pull', unlike clipping of individual fruit as in advanced citrus growing countries like Japan and the United States of America. However, if due care is exercised at the time of 'twisting and pulling' the fruits can be harvested without causing damage.

Yield

The yield varies among species and varieties. It also depends on the age of the tree, care and management and rootstock used. On an average, an adult orange tree may yield about 1,00 to 1,500 fruits, whereas, in the case of limes and lemon, the yield lmay range between 1,000-2,000 and 600-800 fruits per tree, respectively.

Post-harvest Handling

In India, the packaging methods are still crude. They are graded roughly according to size and packed either in wooden crates or bamboo baskets with some cushioning materials for long distance transport by road or train. It is necessary to provide proper ventilation on the top and bottom sides of the cartons. In advanced citrus growing countries, like the Unites States of America, the fruits are individually wrapped in tissue paper and packed in boxes of known capacity for export.

Special Problems and their Controls

(i) Citrus Decline

Citrus decline is a complex disorder, non specific and widespread in almost all the citrus growing countries of the world, including India. The severity and causes may vary from one country to the other, or from one place to the other. A number of factors are found associated with this disorder The important contributory factors are: (a) Soils (b) Environmental conditions (c) Faulty cultural practices (d) Insect pests (e) Diseases and (f) Nutritional disorders.

All or some of these factors may lead the trees to gradual decline. The trees show a variety of symptoms, growth gets reduced, die-back of the twigs appears, the yield gets reduced with poor quality fruits, and the trees gradually decline in vigour and eventually die. If proper care of the plant is taken right from planting, the problem can be mitigated.

(ii) Citrus Granulation

This is one of the important physiological disorders. The exact casual factor is still not clear. It was once believed to be due to deficiency of calcium. which does not hold good any longer.

The major symptoms are drying up

of the juice vesicles, reduction in sugar, and accumulation of polysaccharides like pectin, cellulose and starch. Such affected fruits are unfit for consumption. The granulated fruits have a high content of Ca, Mg and K. The rootstocks ar found to influence the severity of the includence. Rough lemon rootstock was found to influence the severity of the incidence. Rough lemon rootstock was found to induce severe granulation in *Blood Red Malta, Mosambi, Valencia and Pinepple* orange, while *Karna Khatta* rootstock caused granulation in *Jaffa* orange. Incidence of granulation is reported to reduce with the advancing age of trees.

QUESTIONS

1 Mention some of the common citrus species under cultivation in India and give their climatic requirements.

2 Discuss the various methods of propagation of citurs along with their merits and demerits

3 What are the causes of fruit drop in citurs fruits? Give suitable control measures.

4. Explain the following.
   i. Training and pruning in citrus.
   ii. Harmful effects of heavy irrigation on citrus trees.
   iii. Citrus granulation
   iv. Citrus decline

5. Write short notes on
   i. Tristeza
   ii. Greening.
   iii. Citrus canker

CHAPTER 8

Grape

Introduction

The grape is one of the most delicious, refreshing and nourishing fruits of the world It is universally used as a table fruit. It is very easily digested and contains large proportion of sugars and useful minerals.

India has the advantage of not only harvesting grapes over a long period. January to April in the south and June to July in the north, but also of providing the possibility of exporting table grapes to foreign countreies early in the season. Harvesting of table grapes in European countries commences very late .

Origin and Distribution

Grape (*Vitis vinifera* L) has its origin in the region between south of the Caspian and Black Sea in Asia Minor. A large unmber of varieties of grapes have been derived from the species *Vitis vinifera*. Grape cultivation is believed to have been introduced into India in A.D. 1300 by some invaders from Afghanistan and Persia. The Moghal rulers gave considerable importance to grape culture, and thus by the 17th century grape cultivation reached its peak in the Deccan during the regime of Aurangzeb. With the fall of the Moghal empire, viticulture in the north entered into doldrums. Grape was introduced to Mysore (Karnataka) during 1932, while, the Anab-e-Shahi was introduced in Hyderabad (Andhra Pradesh) by Abdul Baquer Khan from the Middle East about the year 1890, which revolutionsed grape cultivation Presently, the average grape yield per unit area of tropical India is the highest in the world The states like Karnataka. Maharashtra, Andhra Pradesh and Tamil Nadu, jointly contribute nearly 90 per cent of the area and production of grapes in India.

In recent years with the introduction of early varieties like *Thompson Seedless, Perlette* and *Beauty Seedless*, grape culture Haryana, Delhi and Western Uttar Pradesh, which fall in the northeastern subtropical region of the country is also gaining momentum.

In Karnataka, grape cultivation has assumed commercial importance in the districts of Bangalore, Kolar, Dharwad, Belgaum, Bijapur, Bellary and Mysore In Maharashtra, Nasik, Aurangabad, Ahmednagar, Pune and Sholapur Districts, and in Andhra Pradesh, Hyderabad, Anantpur, Cuddapah and

Kurnool Districts constitute major grape growing areas.

Botany

Grape belongs to the family Vitaceae which has 12 genera and about 600 species However, *Vitis* is the only genus containing species with commercial value. The genus *Vitis* consists of 60 species and the botanical knowledge of these species is still incomplete. *Vitis vinifera* is a native of Asia Minor and Europe. It produces quality fruits with pulp adhering to the skin. It is susceptible to most of the pests and diseases, but moderately tolerant to salinity.

Vitis labrusca is native of the United States of America and is known as Northern Fox grape the berries are large, round ranging from black to amber colour. The skin is thick and slips from the pulp at maturity. It is cold-hardy and blooms earlier than *vinifera* and is also found to be resistant to several pests and diseases.

Area and Production

The total area under grapes in India is reported to be about 25,000 hectares, producing 4.81 lakh tonnes of mostly table grapes (Table 8.1). More than 80 per cent of the area under grapes is in peninsular Inida, comprising of Karnataka, Maharashtra, Andhra Pradesh and Tamil Nadu States. The grape industry is most advanced in Maharashtra.

Climate

Grape requires a warm dry summer and a cool winter. Temperaturs ranging from 15° to 40°C and annual rainfall of 500-600 mm is ideal for its cultivation. The rainfall should be well distributed but should not coincide with sprouting and the period covering fruit set and ripening. Cloudy weather, high humidity and low temperatures are detrimental as they are highly congenial for the spread of diseases.

Soils

Grapevine grows in varied types of soils from shallow to deep, gravelly, sandy to clay loam and in soils of high to low fertility. Shallow medium black, loamy soils containing a small mixture of lime nodules and soils of 0.5 to 1 m depth with overlying porus sub-soils of *muram* are also suitable for its cultivation But heavy clays, very shallow, poortly drained soils and soils with high alkali salts, boron or other toxic materials are not suitable. The crop can be grown successfully with soil pH ranging from 6.5 to 7.5.

Varieties

Some of the important varieties under cultivation in the country are as below:

(i) Anab-e-Shahi

Anab-e-Shahi is the principal commercial variety of Andhra Pradesh and Karnataka. It is a seeded, very heavy yielding variety, having medium to large sized bunch which is modertely compact and slightly shouldered. The berries are conical, thick skinned, well filled, large to very large, oval, white (pale). It is a sweet grape of excellent eating as well as keeping quality, with low total soluble solids (TSS 16 - 17%), total titratable acidity (0.45 - 0.55%) and late in maturity.

Table 8.1 : Area and Production of Grapes in India

State	Area (ha)	Production (t)	Productivity (t/ha)
Karnataka	6,800	1,29,000	18.97
Maharashtra	10,000	79,000	7.90
Punjab	2,090	56,430	27.00
Tamil Nadu	2,200	45,100	20.50
Andhra Pradesh	1,864	46,600	24.68
Haryana	1,903	47,575	25.00
Total	25,102	4,08,170	16.26

(ii) Bangalore Blue

A variety popular in and around Bangalore in Karnataka. It is variety of medium vigour, seeded, medium yield, small and compact bunches, small to medulum size berries which are spherical with a thick tough skin that slips from the pulp. It has dark blackish purple berries having pale green pulp with good keeping quality. It is highly resistant to anthracnose and downy mildew, and produces two crops in a year.

(iii) Thompson Seedless

An excellent seedless variety which is medium sized, conical to cylindrical shaped, modedrately compact bunches. The berries are small, ellipsoidal, white and of very good quality having a TSS upto 24%. It is best suited for preparation of raisins. This is the most popular variety in Maharashtra.

(iv) Gulabi

An important seeded variety of Karnataka, which has medium vigour and is a fairly good yielder. The bunches are small and very thinly filled and pendulous. The berries are small, purple coloured, spherical with thick skin, sweet soft pulp, good keeping quality, TSS up to 20 per cent and rose flavour. It is an early maturing variety with uneven repening.

(v) Black Champa

A selection made by the Indian Institute of Horticulture Research (IIHR), Bdangalore from introductions made from all over the world. It is suitable for table, juice, dessert and wine purposes. The variety is vigorous, seeded and a medium to high yielder. It has small well filled bunches with medium sized berries which are spherical, bluish black in colour and a very high TSS (25-27 per cent) with good keeping and shipping quality.

(vi) Beauty Seedless

A medium vigoured, seedless and a medium yielding variety bearing medium to large sized compact bunches. The berries are bluish black, medium, spherical, with soft pulp, fair quality and early maturity.

(vii) Arka Kanchan

A variety developed by IIHR, Bangalore

from a cross between *Anab-e-Shahi* and *Queen of Vineyards*, which has medium sized bunches, golden yellow berries with pleasant flavour and high TSS (19 to 22 per cent). It is a heavy yielder and less susceptible to pests and disease than *Anab-e-Shahi*. It is suitable both for table purpose and for making dry white table wine.

(viii) Arka Shyam

This hybird is from a cross between *Bangalore Blue* and *Black Champa* developed by IIHR, Bangalore. It contains (TSS 22-25 per cent). It is good for making dry or sweet red wine, juice and for table purposes.

(ix) Arka Hans

This hybrid is evolved from a cross between *Bangalore Blue* and *Anab-e-Shahi*. The berries are yellowish green, seeded and sweet (TSS 18-20 per cent) and good for fresh table purposes.

(x) Arkavati

A cross between *Black Champa* and *Thompson Seedless* It is seedless and a good yielder. The berries are yellowish green with a thin skin and are very sweet (TSS 22-25 per cent) having a mild pleasant flavour. It is a dual purpose variety good for both table and for making raisins.

Propagation

Grapevines are commercially propagated by stem cuttings, Cuttings having four to six buds for varieties *Anab-e-Shahi* and *Thompson Seedless*, and at least 22 cm long cuttings for other varieties like *Bangalore Blue* and *Gulabi*, should be prepared from high yielding and productive vines, preferably from the October prunings. In North India cuttings are taken from December/January prunings. The buds on the cuttings should be prominent and healthy. Canes that are weak and flat should be avoided. Ideal canes are those which are 0.7-0.8 cm in diameter with internodal lengths of 8-10 cm.

Cuttings are planted in flat beds leaving two nodes above the soil surface. A mixture of leaf mould, Farmyard manure, sand and super-phosphate (2:2:1:1:4) is applied to the nursery beds before planting the cuttings. To protect the cuttings from termite attack, Chlordance or Heptachlor 6 per cent dust is applied to the nursery before planting. The rooted cuttings are ready for planting in the field in about four months after planting in the nursery.

Thompson Seedless cuttings do not root easily. Soaking the basal 2 cm length of the cuttings into 250 ppm of Indole butyric acid (IBA) solution for 12 hours and planting, has been found to improve rooting.

Propagation by Grafting or Budding

The use of rootstocks is recommended to combat root infesting pest namely *Phylloxera* and plant parasitic nematodes, particularly the root-knot nematodes (*Meloidogyne spp*) which are very serious in some localities. The desired scion varieties are grafted on to resistant ones by adopting chip budding or bench grafting, or *in-situ* field grafting techniques.

Lay out Plan for *Bower* System of Traing

The site selected for grape planting is to be levelled or laid into terraces to

facilitate surface irrigation. The plot is thoroughly ploughed to remove weeds. A base line is fixed parallel to a permanent feature such as a road or hedge. On this line a rectangular or a square plot is laid out as required. A compact vineyard unit should not be more than half a hectare. Plant and pillar positions are marked for *bower* erection, depending upon the spacing required between the vines. Care should be taken to align pillars and vines in one line.

Spacing

Spacing varies with the vigour of the varieties and the type of training and pruning that is envisaged. The commonly followed speacing are 4.5m x 4.5m, 6.6m x 3.3m for *Anab-e-Shahi* and *Bangalore Blue* and 3.0m x 3.0m, 1 8m x 1.2m for *Thompson Seedless*. Recent trends are to reduce the vine spread and accommodate more vines per unit area to get increased returns in the early years of vine growth.

Planting

Planting should not be taken up until the layout and *bower* erections are complete. For wider spaced vines, pits measuring 90 cm^3 are dug one month in advance of planting the rooted cuttings. For closer spaced vines trenches of 90 cm depth and width and of the required length are opened. The distance between two trenches is the spacing to be given between the rows of the vines and within the trench the desired spacing between vines is given. The pits or trenches are subjected to weathering for about a month. Each pit is filled with a mixture of soil, 50 kg farmyard manure, 2 kg bonemeal, 3 kg castor cake or neem cake and 2 kg superphosphate Water is let in copiously into the pits in order to make the soil sink and settle. Later, pits are filled once again to ground level. To protect the plants from white ants attack, 10 per cent BHC or Heptachlor 6 per cent dust is mixed wtih sand and applied in the centre of th pit where the plant is to be planted. Before lifting the cuttings, leaves and green shoots are removed and only 3 to 4 buds are left on the mature shoot. Raising plants in pots or polythene bags is desirable as their survival in the field is better. The ideal time for planting in the field is between Novermer to January

Training

Training of grapevine is important as it helps to maintain the framework and spread of the vine in a way that is convenient to carry on operations like pruning, interculturing, spraying and harvesting. The training system depends mainly on the nature of the vine with reference to its apical dominance and vigour.

Although a number of training systems are known, only *Bower*, Kniffin, Telephone and Head systems are followed in India *Bower system*. The bower system is also known as the Pendal system of training and is the most suitable system for vigorous and semi-vigorous varieties of grapes. The *bower* is erected using granite stone pillars. Galvanised iron wires of 5.8 and 10 gauge thickness and turning buckles are some of the materials used While training, only the best growing shoot from the plant is allowed to grow upright (2-2.25m) The main stem is pinched about 15 cm below the *bower* and two side shoots are allowed to grow and spread horizontally in opposite directions over the *bower*. These shoots form the arms (primaries) subsequently.

on which the secondaries are allowed at intervals of 45 cm. These in turn give rise to tertiaries on which canes develop and produce the shoots carrying bunches

Item	Cost (Rs.)
1 Land preparation (ploughing, leveling trenching, bending).	2,225.00
2 Cost of stone pillars 323 Nos (275 cm x 20 cm x 10 cm size) at Rs 12 per pillar and cost of erection of pillars (317 men labourers)	12,410 00
3 Galvanised wire of 6,8,10, 12 and 15 sauge (22,862 kgs)	20,570.00
4. Fencing (190 stone pillars, 508 kg barbed wire)	4,220 00
5. miscellaneous	475.00
Total	Rs 50,000.00

Among all the training system although *Bower* is the most expensive, the cost benefit ratio is also quite high in this system in the long run. A tentative break-up of figures of the cost establishment of one hectare of grape vineyard is as indicated below:

Kniffin system. This system is not as common as the *bower* system. It is suitable for moderately vigorous varieties with less apical dominance. Closer planting (8.1 m) within the row, and 3 m between the rows is adopted for this system. Galvanised iron wire of 8 gauge thickenss is sttretched parallel to the ground at a height of 75 cm above which two more wires are stretched at a successive height of 60 cm. When the plant crosses the first wire, it is pinched leaving a bud above the wire. As a consequence of this two laterals are developed in either side of the plant along the wire and the terminal shoot is allowed to grow vertically. Similarly, a pair of laterals are developed along the second and the third wire. In some cases only two pairs of laterals are developed at heights of 1 35 m and 1.95 m from ground level and this is called 'Four-Farm Kniffin' system.

Telephone system: This system is suitable for moderately vigorous varieties with more apical dominance. This system is an improvement over the *Bower* system with respect to ventilation and light penetration. It is relatively less expensive than the *Bower*, but more expensive than the *Kniffin* system.

In this case, a trellis is erected by using granite stone pillars of 240 cm length and 15 sq. cm thick at the corner ends and pillars of 230 cm length and of thickness of 10 sq cm in the midle of the line. The middle pillars are spaced at 6 m distance with cross arms of 1.3 m angular iron of 10 sq. cm thickness Three wires of 8 gauge galvanised iron are pulled horizontally over the cross arms at a regular spacing of 60 cm using turning buckles at the end pillars. The end pillars are supported sidewards and the vines are trained on the wire

Head system This is the least expensive system of training. Plants are spaced very closely (1.5 x 1.5 m) to accommodate over 4,000 plants per hectare. Less vigorous varieties are suitable for this system. In this case the plant is topped at 1 m above ground level from where two lateral branches are encouraged and it is topped again at 1.3 m height, from where two more laterals are developed. The laterals are allowed to grow to a length of 45 cm and only fruiting canes are deyelped on these laterals. Livestakes of *Erythrina indica* or *Commiphora berry* are provided to the ines.

Pruning

Pruning is done only once in North India

during January to make the fruitful buds sprout, but in Southern India pruning is done twice a years, once during summer and again in winter. Grapevines in the southern region grow continuously without any dormacy. Hence, by pruning in April (summer) the vines are forced to have rest which helps in the fruit bud differentiation. Pruning time mainly depends on rainfall and temperature. It is so adjusted that there is no coincidence of rainfall with fresh growth and flowering and also that winter does not set in within 10 to 15 days after pruing.

Summer pruning: Summer pruning is done during March-April. In this pruning, all the leaves are removed and canes are cut back to one or two buds for forcing new vegetative growth. Hence, it is also called "Back Pruning" or "Foundation Pruning" or "Growth Pruning". The dried and weak canes are completely removed.

Winter Pruning: This pruning is done during the second or third week of October, but any time during October is satisfactory. Before this pruning, the vines are given a rest by withholding irrigation for about 3 weeks and basins are dug to a depth of 15 cm. The mature current season canes (about 6 months old) are pruned. The entire foliage and immature shoots are removed

The level of pruning differs with varieties. While *Anab-e-Shahi* is pruned to 5-7 buds, *Thompson Seedless* is pruned to 8-10 buds, *Bangalore Blue* to 4 buds, and Gulabi to 5-9 buds. More buds are retained on thicker canes and less on thinner ones. This pruning is also called forward pruning To increase the bud break after winter pruning, cane twisting is desirable. Spraying the canes with Thiourea at 3 per cent within 48 hours of pruning is also effective in increasing the bud burst during winter.

In varieties like *Bangalore Blue* and *Gulabi* in Karnataka the vines are pruned for cropping twice. Instead of back pruning, forward pruning is done in summer also leaving 4 to 6 buds. Particularly in *Bangalore Blue*, the vineyard is usually divided into blocks and pruning time is staggered in such a way that the fruits are available almost throughout the year

It is, therefore, not uncommon to see all stages of growth ranging from vines having sprouts to those with mature crops in the same vineyard.

Fruitfulness of buds varies from one year to another, depending upon the weather, nutrition, load of previous cropping, etc. Hence, growers are advised to seek professional guidance regarding the level of prunng based on bud analysis.

How to Select Shoots for Bud Analysis

(i) Collect shoots 15 to 30 days before pruning.

(ii) Walk diagonally in the vineyard and count the steps. Divide the number of steps by six to make six spots equidistant from each other.

(iii) Collect one shoot sample at each spot. While collecting the sample, do not look at the vine. After selection, cut such selected shoots by leaving the first three basal nodes of the shoots from the other diagonal. In all, 12 shoots are to be collected for every 0.4 ha of grape plot separately.

(iv) Remove all the leaves and make a bundle of the samples with a label containing the address and also the number of nodes left on the shoot, etc. The sample should be sent to the laboratory for analysis as early as possible.

Points to be Borne in Mind While Pruning

Pruing is an important and crucial operation in grape growing Hence, much care and precatuions are to be exercised in pruning the vines. Wise purning envisages less depressing effect on the vine but more concentration of the activity in the parts left after pruning. Light pruning i.e. retention of less canes results in a light crop. A vine in a given season can properly nourish only a certain quantity of fruit Hence, while pruning vigorous vines, more canes are retained and in less vigorous vines a smaller number of canes are retained. If a vine has given a heavy crop during the previous season, it has to be pruned severely during the next fruiting season to maintatain the balance.

Interculture

Bullock drawn or tractor drawn implements can be used for inter-cultivation and weed control, if sufficient space is provided between vines and beneath the *Pendal*. In a vineyard where close spacing is adopted, manual weeding or digging the plots once in three months to remove weeds is a common practice. As manual labour is becoming costly, preemergent application of Diuron at the rate of 2 kg active ingredient per hectare is recommended to control most of the weeds for a period of six months.

Manuring

Normally very heavy fertiliser dressings are given to *Anab-e-Shahi* and *Thompson Seedless* grapes. In addition to the manure used while filling the pits, the following manure and fertilisers are applied to the vines during different years of growth for all grape varieties in general and for *Anab-e-Shahi* variety in particular.

First Year

In addition to the manure applied at the rate of 100 kg per vine while filling the pits, each vine should receive a monthly application of 100 g urea and 300 g superphosphate. The fertilisers should be applied at a distance of 30 cm from the vine. Monthly top dressing will make the vine grow fast and cover the *bower* quickly.

Second year onwards

	Second to fifth year (kg/ha)			*Fifth year onwards (kg/ha)*		
	N	*P*	*K*	*N*	*P*	*K*
1. At April pruning	150	125	-	300	250	-
2 35-40 days later	150	-	300	300	-	400
3 At October pruning	200	125	225	400	250	300
4 60 days later	-	-	225	-	-	300
Total	500	250	750	1000	500	1000

Irrigation

Grape is grown in India under irrigated conditions and the water requirement of vines is different during different stages of growth Vines are irrigated immediately after fertiliser application and pruning. During the early growth stage, irrigation is given at intervals of 5 to 7 days Water is withheld for at least 8-10 days prior to harvesting to improve the fruit quality. Irrigation is rsumed 12-15 days after pruning. During the period from the summer pruning to the onset of rains, irrigation is given weekly and thereafter at 10-12 days interval until the winter pruning, depending upon soil moisture. Frequent and copious irrigation is to be avoided for 45-60 days after summer pruning as it adversely affects the flower bud differentiation. Similarly, too frequent and heavy irrigation from flower opening to pea size of the berries should also be avoided, as it increases incidence of downy mildew. Irrigation is completely stopped a week before harvest to increase sweetness.

Techniques to Improve Grape Quality

The production of quality grapes depends on uniform clusters, perfect berrics with characteristic colour, pleasing flavour and texture of the variety.

Techniques like girdling, thinning and application of plant growth regulators can bring about various beneficial effects on berry set, size, colour, ripening and cluster compactness, etc. These are explained below:

Girdling: Girdling is the removal of a complete ring of bark 3.3-6.4 mm wide on the trunk at a distance of one metre from ground level, on arms 10 to 15 cm from the base of the arm, on canes one node below the first bunch on the cane. Girdling at bloom increases the number of seedless berries. If girdle is kept open during rapid growth of the berries, the size of seedless berries is increasd from 30 to 100 per cent In *Thompson Seedless* girdling should be done immediately after fruits set to increase berry size. Girdling also hastens colouration at maturation which will help to reach the market early to obtaion a higher price.

As girdling stops the downward movement of food materials, prolonged girdling, particularly of the arm and the trunk makes the roots starve after utilisation of the reserve food The top growth is retarded and the leaves may turn yellow as a result of serious weakening effect on the vine. Any girdled portion should not remain open for more than 3 to 4 weeks. Immediately after girdling the vines shluld be irrigated to keep the soil moist until the girdles are healed. Overbearing of girdled vines should be avoided, and while girdling only the bark should be removed. Cutting too deep into the wood is harmful as it destroys most of the active conducting vessels, resulting in stunted growth or death.

Thinning

The purpose of thinning is to reduce the grape crop to a reasonable load so that high quality fruits are produced. The main types of thinning are as follows:

(a) Flower Cluster Thinning

The rudimentary flower clusters are removed without removing the leaves. Thus the retained clusters are improved

Insect/ Disease	Period of occurraence	Nature of damage	Control measures
Major Insects			
i Flea beetle *Scelodonta strigicollis*	Immediately after pruning, mostly in July	Feeds on the sprouting buds and tender growth by cutting holes and scraping the leaf surface.	Spray 0.05 per centt Quinalphos four days after pruning
ii. Chaffer beetles (*Adoretus sp.)*	Onset of monsoon	Beetles come out at night and feed voraciously on young shoots and leaves, hide isn the nearby shrubs during daytime.	Spray Monocrotophos or Quinalphos at 0.05 per cent concentration
iii. Thrips (*Rhipiphorothrips cruentalus*)	October to December	Found in the lower side of the young leaves sucks sap from leaves, ovaries of flowers, leaves curl downwards, scab formation	Spray Methyl parathion 0.05 per cent at weekly intervals commencing from 8-10 10 days after pruning
iv Spider Mites (*Oilgonychus (sp*)	May to August	Sucks sap from the upper surface of leaves. Leaves turn greyish brown, dry and drop down	Spray 0.04 per cent Dicofol; 0 06 per cent Dimethoate; or 0 05 per cent Monocrotophos
Major Diseases			
i Downy Mildew *(Plasmopara viticola)*	Humid cool weather, mostly during July-August and November - December	Whitish downy growth in patches on the lower surface of the leaf. Corresponding upper surface shows yellow patches. The yellow patches dry up and the leaves drop in severe cases. Flowers and young fruits are also affected; flowers wither and drop. Young fruits become water soaked, leathery and drop	Spraying 1.0 per cent Bordeaux mixture or any copper fungicide repeatedly at weekly intervals during July-August and 3-4 days intervals during Nov-December
ii. Anthraccnose (*Gloeosporium ampelophagum*)	Rainy season mostly during May-July and October-December	Attacks fresh growth Dark brown lesions with black centres develop on young shoots, leaves, tendrils and on young berries In case of severe damage the shoots become crinkled and leaves show shot holes.	Spray 0.8 per cent Bordeaux mixture or 0 3 per cent Difolatan regularly at 4-5 days interval during May to July and October to December
iii Powdery mildew (*Uncinula necator*)	Dry winter December-February	Whitish patches appear on leaves, tender shoots and berries. When young berries are affected they become hard, mummified and crack.	Spray wettable sulphur (0.2 per cent) or dusting sulphur at 18 kg/ha regularly at 5-7 days interval during December to February

due to good nutrition resulting in a better set of normal berries. In *Thompson Seedless* if the crop is excessive, flower cluster thinning helps to obtain better quality and also to reduce the compactness of the bunch.

(b) Cluster thinning

This is the removal of entire clusters after the berries are set. The apical end of the main stem is cut off so that 4-8 branches are retained at the base of the cluster depending on their size. Berry thinning improves quality, colouration and maturation. The varieties like *Tokay* and *Thompson Seedless* are berry-thinned to keep the cluster from becoming too compact and to increase the berry size

Use of growth regulators

Bunch compactness in *Thompson Seedless* can be overcome by treating the panicles with 15 ppm gibberellic acid solution (15 mg/litre of water) at full bloom stage. To improve the berry size and visual appeal, bunches are to be dipped in 60 ppm gibberellic acid for 10 seconds at fruit set stage. To reduce the small berry formation in *Gulabi*, application of 50 ppm gibberellic acid solution (50 mg/litre of water) to the panicles at 5-6 days after full bloom is recommended.

Plant Protection

Grapevines suffer more from diseases than from insect pests. The period of occurrence, nature of damage and control measures for important pests and diseases are given in the Table on page 69.

Removal of the loose bark from the main stem and primary branches and smearing with Bordeaux paste will help in minimising the incidence of many pests and diseases.

Nutritional/Physiological Disorders

(a) Interveinal Chlorosis

The disorder is of common occurrence in *Anab-e-Shahi* grapes around Hyderabad This is more promounced at the fruits maturity stage. The area between the veins becomes yellowish. In severe cases the leaf tips dry up. This disorder is attributed to magnesium deficiency, probably induced by excessive fertilisation with potash

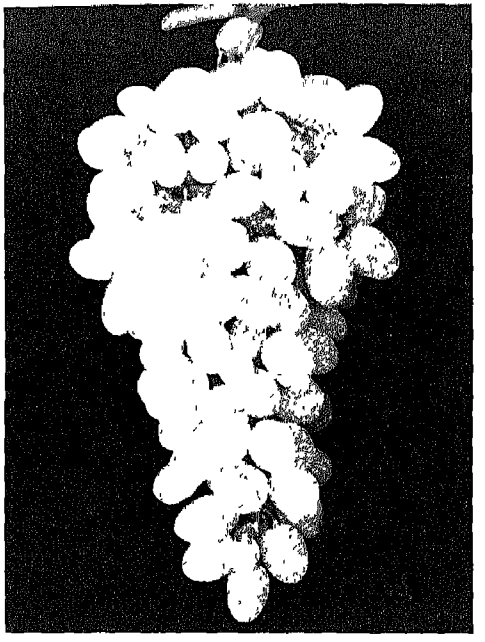
Suggested remedial measure is spraying with 0.5 per cent solution of neutralised magnesium sulphate during the fruit development stage Two to three sprays at an interval of 20 to 30 days are effective in minimising this problem

(b) Blossom-end Rot

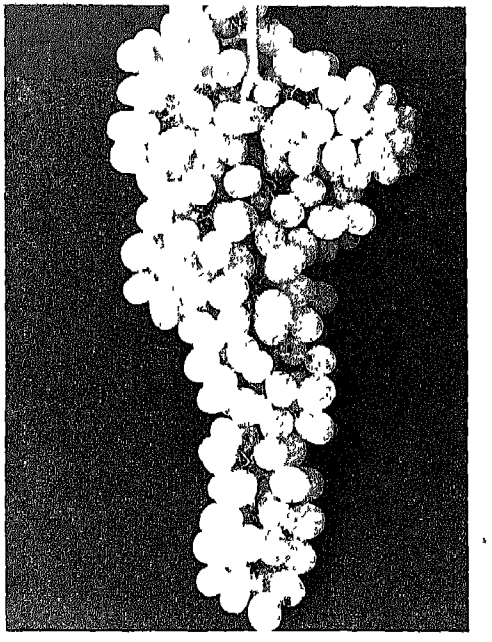
This disorder also has been reported from the Hyderabad region in *Anab-e-Shahi* grape. Initially a black sunken spot develops at the blossom-end of the berry. This spot goes on spreading with the water soaked region around it. Finally the affecterd area becomes rotten. Defective calcium assimilation by the growing berries seem to be the cause.

Usage of good quality irrigation water, avoiding copious irrigation after prolonged drought, spraying with 0.2 per cent calcium sulphate solution or application of lime to the soil are some of the suggested remedies for this disorder.

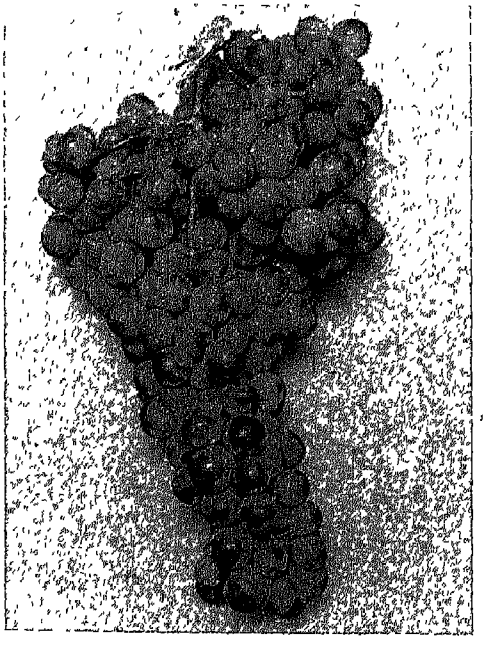
GRAPE VARIETIES



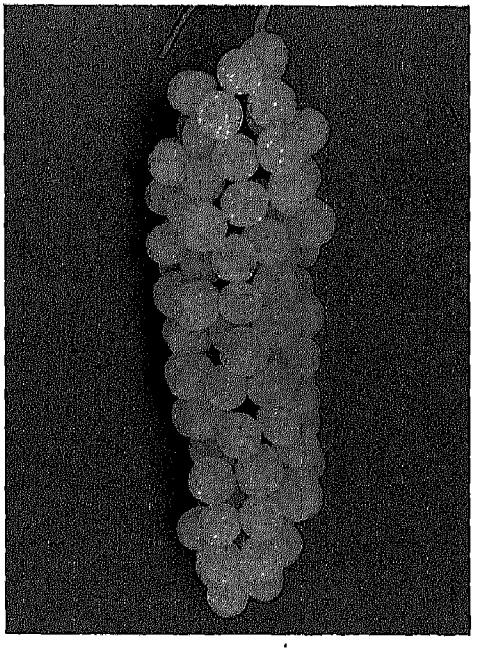
Anab-E- Shahı



Arkavatı



Gulabi



Arka Hans

TRAINING IN GRAPES

Kniffin System

Bower System

Bearing of Sapota (Variety-Kalipatti)

Approach Grafting in Sapota

(c) Dead Arm

Dead arm is of common occurrence in regions of hot summer, particularly in *Anab-e-Shahi* in the Rayalasema District of Andhra Pradesh. Part of a primary arm or secondary branch suddenly dries up and eventually dies. Secondary branches are mostly affected. Roots and stem of the wilted plant show partial discolouration in distinct sectors running through the roots and affected branches. This disorder is attributed to high temperature, hot winds and scanty and improper irrigation. Severe pruning of the affected branches is the only remedial measure for this disorder.

(d) Flower and Flower Bud Drop

This phenomenon has been reported from North India in the states of Punjab, Haryana and Rajasthan Flowers drop from the clusters just before and after opening. Considerable yield reduction has been reported due to this disorder. The etiology of this malady has been investigated and the association of number of factors, such as atmospheric temperature, high phosphorus and salt content of the soil have been reported to be associated with this disorder. Correct choice of the site is important in overcoming this problem.

(é) Cluster Tip Wilting

This is a common disorder in *Thompson Seedless* grape bunches at maturity. Light brown small lesions on the apical end of the rachis are seen. Conductivity of the rachis are affected, resulting in shrivelling and drying of berries at the tip of the bunch. This disorder was found to be more under moisture deficit conditions and also in vines with heavy crop loads. Crop load and irrigation should be regulated to avoid the problem.

(f) Pink Berry Formation

This is a serious problem of *Thompson Seedless* in Maharashtra As the bunch approaches the harvesting stage, some random berries develop pink colour. Such berries turn black within a day after harvesting and the bunch becomes unmarketable. Incidence of pink berries is low in the early season crop and increases with rising temperatures late in the season. Indiscriminate use of ethrel for berry colouration could also cause this disorder. Pruning at right time is necessay for timely crop.

(g) Poor Cane Maturity

Poor cane maturity is a common phenomenon observed in peninsular India. It is more in vineyards where the shoot growth is vigorous and dense, vines are planted closely and excess nitorgen and irrigation are given. The previous season's crop load is also found to affect the shoot-maturity. Suggested remedial measures include cultural practices to check excessive vegetative growth so as to prevent mutual shading of shoots and promote light interception

Harvesting

Grape bunches are harvested when they are fully ripe on the vine, as there will be no further ripening of the berries after the bunches are cut from the vine. The time taken from fruit set to ripening depends on the variety, crop load and the atmospheric temperature. Hence, the time required for ripening in one region

may not be the same as in other regions in the same variety. Thus the "heat unit concept" is safe to follow for determining the optimum stage of harvest. The heat units are known as 'Degree days'. These are calculated by subtracting 50 F (base temperature) from the mean of the daily minimum and maximum temperatures measured in Fahrenheit scale

Example

— Maximum temperature in a day 34°C
— Minimum temperatute in a day 20° C
— Mean of the temperature $\frac{34+20}{2}$ =27°C or 80°C

Heat units of the day =30 (80-50) degree days. When the summation of the degree days from the day of full bloom to the proposed day of harvest comes to 1600-2000, early varieties like *Thompson Seedless* can be harvested.

It is further observed that under Hyderabad conditions in the case of *Anab-e-Shahi*, the ripening is delayed by one day for every additional tonne of yield over 38 tonnes per hectare. This approach for judging the maturity is too exacting, laborious and does not apply for all bunches growing on the same vine. However, it gives a rough idea of the time of ripening. The ripeness of the individual bunches is judged based on the following indications.

i. When the lower most berry of a bunch becomes soft and sweet, the bunch is harvested.
ii On ripening, the white grapes turn amber and the coloured ones attain a dark and uniform characteristic colour.
iii Seeds of the ripe berries become dark brown. These colour changes indicated above are the generally accepted standards of ripeness for harvesting

QUESTIONS

1 Why is it possible to get two crops in peninsular India compared to only one crop in North India?
2 List some of the recently evolved grape hybrids along with their characteristics
3. Discuss the various techniques to improve fruit quality in grapes.
4 What do you understand by 'heat unit concept' of harvesting? Discuss in detail
5 Differentiate between the following
   i Dessert and wine grapes. ii. Raisin and table varieties.
   iii. *Vitis vinifera* and *Vitis labrusca*
6 Write short notes on:
   i Interveinal chlorosis in grape ii Blossom end rot of grape berries
   iii Dead arm in grape iv Poor cane maturity
   v Cluster tip wilting

CHAPTER 9

Sapota

Introduction

Sapota is grown only for its delicious fruits in India, Mexico and Guatemala. Its latex is commercially extracted from the bark for manufacture of chewing gum. Besides being used as a dessert fruit, the fruits are also used in the preparation of jam, and for canning as slices.

Origin and Distribution

Sapota (*Manilkara achras syn. Achras sapota* L.), also called *Chiku* or Sapodilla, is a native of Mexico in tropical America. It is commercially cultivated in India, the Philippines, Sri Lanka, Guatemala, British Honduras and Mexico. In India it was introduced at the fag end of the 19th century and is chiefly grown in the moist coastal tracts of the country. In recent years, its cultivation has spread to the drier zones of the Deccan plateau. It is grown as a commercial fruit in Maharashtra, Gujarat, Andhra Pradesh, Karnataka and Tamil Nadu. In India sapota is grown in are area of 37,837 hectares (Table 9.1).

Table 9.1 : Area and Production of Sapota in India

State	*Area (ha)*	*Production (t)*	*Productivity (t/ha)*
Andhra Praesh	3,490	29,840	8.50
Gujarat	15,000	1,80,800	12.00
Karnataka	11,440	2,02,902	17.24
Maharashtra	5,000	80,000	16.00
Tamil Nadu	780	12,150	15.27
West Bengal	1,327	7,960	6.00
Others	800	9,500	11.87
Total	37,837	9,500	13 80

Botany

Sapota is an evergreen tree growing up to 20 m height in Mixico and Central America. The fruits are elliptical to ovate, 5 to 15 cm long and 2.5 to 6 cm in diameter, and grayish to rusty brown with yellowish brown flesh. The seeds are 2-8 hard, black and easily separated from the pulp. The unripe fruits are astringent and latex is present in all parts of the plant.

Climate

Sapota is a tropical fruit crop and can be grown from sea level to 1,200 m elevation. It grows and fruits fairly well under a variety of wet and dry climates all over peninsular Inida. It bears a better crop at elevations up to 500 m and nearer the coastal area than inland. Areas with an annual rainfall of 125 to 2,500 mm are highly suitable. The optimum range of temperature for growth is 11° to 35°C. Higher temperatures above 41°C during the summer months cause drying of the stigmatic fluid, flower drop and leaf and fruit scorching. Fully grown trees can withstand mild frost for a short period, but young plants are injured.

Soils

Sapota is a hardy tree and can be grown on a wide range of soils. Well drained alluvial soils on the banks of rivers, sandy loams along the sea coast and red loamy soils are suitable for sapota cultivation. Soils containing a high percentage of lime or underlined with a hard substratum in the sub soils are not suitable. Black cotton soils or clayey soils with poor drainage are also unsuitable for growing sapota.

Varieties

There are several varieties of sapota under cultivation in India. Some of the prominent varieties of India are indicated below:

(i) Cricket Ball

Known as *Calcutta Large*, it is grown in Tamil Nadu, Karnataka, Maharashtra, West Bengal and Andhra Pradesh. The leaves are light green. The fruits are round in shape and large in size. The pulp is gritty and granular and not very sweet. It is a shy bearer and does well in an arid climate and at elevations up to 300 m.

(ii) Kalipatti

Kalipatti is a leading variety of Maharasthtra, Gujarat and Karnataka State. The leaves are dark green, broad and thick. The fruits re medium sized, oval shped, less seeded with sweet yellow flesh of excellent quality. The fruits re borne singly on terminal growth. A 10 year old tree of this variety may yield about 100-150 kg of fruits per year.

(iii) Oval

The variety is grown in Karnataka and Andhra Pradesh. The fruits are small and oval or egg shaped with a broadly pointed apex. The pulp is very sweet. The bearing is heavy and fruits are borne in clusters. The fruit has thin skin and good flavour. The trees grow sparsely and are susceptible to leaf spot disease.

(iv) Calcutta Round

This variety is grown in West Bengal and Karnataka. the foliage is light green in colour. The fruits are medium sized and susceptible to leaf spot disease. It is not preferred by growers.

(v) PKM-1

This is a selection from the variety *Guthi* and released from Periyakulum in Tamil

Nadu. It is reported to be dwarf in stature and has a high yield potential. The fruits are oblong, medium in size, with thin skin and have more pulp with sweet taste. The variety is suitable for high density planting.

(vi) CO-1

A hybrid from the cross between *Cricket Ball* and *Oval*. The fruit is oval, medium sized with TSS of 18° Brix. Each fruit weighs about 125 g and is bigger than *Oval* and sweeter than the *Cricket Ball* variety. The average fruit yield is 175-200 kg/tree per year.

(vii) CO-2

CO-2 is a clonal selection from the *Baramasi* variety of sapota. The fruits are large in size, weighing about 200 g each, with high TSS of 23° Brix. The normal yield is 75 kg per tree per year. It is a rather shy bearing variety and not much preferred by growers.

(viii) DHS-1

DHS-1 is as hybrid evolved by crossing *Kalipatti* and *Cricket Ball* varieties, released from Dharwad in Karnataka. The fruits are large, round with attractive light orange brown coloured pulp. The average fruit weight is 210 g and has a high TSS of 23° Brix. Because of its good quality and higher yield it shows great promise.

(ix) DHS-2

This is auother hybrid of the parents *Kalipatti* and *Cricket Ball*, and released from Dharwad. The fruits of this hybrid are medium sized, oblong with light orange coloured pulp. The average fruit weight is 1509 with the highest TSS of 26° Brix.

Propagation

Sapota is at present commercially propagated mainly by vegetative methods like air layering and approach grafting. Soft wood grafting is also being adopted for commercial propagation in recent years.

Air Layering

During the monsoon season, 2-3 season old healthy shoots of 45-60 cm length and 0.6-1.0 cm thickness, are selected for air layering. At the basal end of the shoot, a ring of bark of about 2.5 to 3.0 cm length is removed and it is covered with moist sphagnum moss or Vermiculite and wrapped with polythene film. The rooting can be improved by the application of 10,000 ppm mixture of growth regulators IBA and NAA. The roots emerge in about 3 months and the air layers are separated gradually in about 4-6 weeks by successive deepening of the cut below the air layered portion.

Inarch Grafting

This is the commercial method of propagation in sapota. The rootstocks are raised in pots and they are inarch grafted with the desired variety. The scion remains attached to the parent tree till the union is complete in about 21/2-3 months. Afterwards, the grafts are separated gradually in about 4-6 weeks time by successive deepening of the cuts below the scion and above the graft union. Of all the rootstocks tried, *Rayan (Khirni* or *Manilkhara hexandra)* has been found to be the most suitable for sapota, as such plants develop an extensive root system, grow vigorously and produce heavy yields.

Khirni (Rayan) seeds should be used, when fresh, as they are slow to germinatie and lose their viability very soon. For improvement in germination, the seeds

are soaked in hot water at 60° C for 5 minutes. Soaking the seeds in thiourea 0.5 per cent solution for 24 hours also improves the germination. The seeds require about 4 weeks for germination.

Comparison of Grafts and Layers

The plants propagated through air layering have a shallow root system, with the majority of them occupying 30-60 cm depth of top-soil and hence, do well both in shallow and deep soils.

On the other hand, the grafted plants on 'Rayan'develop deeper root systems, with roots concentrating in 60-90 cm of top-soil. Therefore, grafts do well in deeper soils.

Planting

Deep ploughing, harrowing, removal of perennial weeds and levelling are some of the important operations to be taken up while preparing the land. A strong windreak should be planted on the windward side to protect the bearing trees from wind damdage. Planting is done in the beginning of the monsoon in the plains and at the close of the monsoon season in heavy rainfall areas. For planting, pits of 75 x 75 cm (75 cm^3) size are dug and filled with top-soil mixed with farmyard manure in equal proportions adopting the spacing of 10 x 10 m. The plants are staked immediately after planting.

The young trees are taken care of by watering regularly during the dry season, hand digging of basins occasionally removing weeds and manuring.

Training and Pruning

Pruning is not required during the first 10 years except for the removal of growth from the rootstock as sapota grows into a shapely tree left to itself. However, in later years, particularly in layers, the basal branches become unfruitful and are removed by skirting the treee to about 90 to 120 cm from the ground.

Intercropping

Sapota grow slowly and there is a large inter row space available in young orchards. Short duration fruits like banana, papaya or leguminous vegetables like cowpea, cluster bean, lima bean, peas, etc., can provide extra income to the farmer. Green manuring crops can also be grown and incorporated in the soil. Usually intercrops are grown during the first 8 to 10 years to fetch additional returns.

Age	*Nutrients/tree (g)*			*Organic manure (kg)*	*Fertilisers/tree/year (g)*		
	N	P_2O_5	K_2O	*FYM*	*AS*	*SSP*	*MP*
1-3 years	50	20	75	50	250	125	125
4-6 years	100	40	150	50	500	250	250
7-10 years	200	80	300	50	1000	500	500
11 yrs and more	400	160	450	50	2000	1000	750

AS . Ammonium Sulphate; SSP : Single super phosphate; MP : Muriate of potash

Manuring and Fertilisation

For optimum growth and yields, manure and fertilisers should be applied to sapota plants in proper doses. Addition of phosphous is of particular importance, as it imporoves the fruits size and its deficieny results in hard and small sized fruits. The manure and fertilisers should be applied in two split doses. The first dose is applied with the onset of the monsoon (June-Jsuly), and the second at the end of the South-west monsoon (October-November). The fertiliser schedule is given below:

Irrigation

Sapota can withstand drought conditions and it is onsidered one of the most economcally important dryland horticulture fruit crops. However, young plants require protective irrigation at least during the first two summer seasons for better establishment and growth. In irrigated orchards under tropical conditions, irrigations at an interval of 20 days in summer and 30 days in winter are recommended.

Flowering and Fruiting

Sapota fruits mature in about 9 to 10 months from flowering and fruits set. However, the time taken from flowers to harvest varies with the variety and climateic conditions. In humid and warm tropics the trees flower almost throughout the year, but more profusely in May-June and January-February, the corresponding fruiting seasons are March-May-June and January-February, the corresponding fruiting seasons are March-May and September-October. The fruits harvested during March-May months are found to be sweeter.

Plant Protection

(a) Major Insects and Their Control

(i) *Chiku* Moth/Bud Borer *(Nephopteryx eugraphella)*

This is the most serious pest of sapota. The caterpillar feeds on buds, leaves and young fruits and causes heavy crop losses. This can be controlled by spraying 0.1 per cent Nuvacron or calcium arsenate.

(ii) Stem Borer (*Arbela tetraonis*)

This is larva bores into the bark of the trunk and its presence can be detected from the chewed bark thrown out of the hole in the trunk.

The grubs can be killed by inserting a stiff wire into the tunnel. The hole is plugged with a wad of cotton dipped in kerosene or BHC 0.1 per cent; and plastered with wet mud. The borer gets suffocated and dies inside the tree.

(iii) Scale Insects (*Palvinaria psidii*)

These insects have green brown scales and are oval in shape. They infest along the sides of the midrib and surface of leaves and tender twigs. They suck the sap and secrete large quantities of a sugary substance, over which black fungus (sooty mould) develops.

The scale insects are controlled by spraying Dimethoate at 2 ml/litre. Two or more sprays may be required for effective control.

(iv) Fruit-Fly *(Dacus dorsalis)*

This ia also becoming an important pest damaging fruit wherever the grub feeds on the pulp and renders them unfit for marketing. But spray suggested for mango is effective in sapota also. Carbaryl 0.2 per cent + 0.1 per cent protein hydrolysate or molasses are sprayed at fifteen days interval. Poisoned Methyl-eugenol traps are also effective.

b. Major Diseases and Their Control

(i) Leaf Spot (*Pharophleospora indica*)

This disease causes conspicuous dark brown circular spots on the leaves. In due course these spots enlarge and colaece and cause defoliation. The disease is more serious in South India during the rainy season.

(ii) Sooty Mould (*Capnodium sp.*)

This disease develops on honey dew like excretions of the scale insects and covers the leaves affecting photosynthesis.

Sooty mould can be controlled by spraying 0.5 per cent starch solution (5g starch in 1 litre of water). On drying, the starch forms thin flakes and drops off, removing the mould along with it. Simultaneously spraying insecticide to control scales should be done.

Maturity and Harvesting

Sapota fruits ripen after harvesting and they have to be harvested at the fully matured stage. The maturity can be judged in several ways before harvest. Mature fruit develops a dull orange or potato colour. The brown scaly material, known as 'scruff', starts falling from the fruits and the milky latex content is reduced and turns watery at maturity. The dried spine-like stigma at the tip of the fruit falls or drops off easily when touched. When a mature fruit is scratched it shows a light yellow streak instead of green streak which is a sign of immaturity. Fruits are individually hand plucked or a harvester is used.

Yield

Though sapota trees may start producing fruits by the fifth year economic yields can be obtained only between the eighth to tenth years.

The production increases from 500 fruits per tree from the fifth year to 2,500-3,000 fruits per year from the 25th year onwards. Average production is about 14 tonnes per hectare.

Packing

Fruits after harvest are washed in running water or dry cleaned by rubbing with a gunny bag. Then they are greaded in three grades based on size and packed. For transportation to distant places, graaded fruits are packed and sent immediately after harvest, in bamboo baskets using paddy straw, or paper shreds as cushioning material for protection. At 11° to 13.5° C. unripe hard fruits ripen slowly and can be stored in good condition for 4-5 weeks. For packing, cardboard boxes are also being used.

Ripening

Sapota fruits keep well for 7-8 days after picking. Under warm conditions the fruits ripen in about 5 days and the latex disappears. Ripe fruits can be stored for

about 6 weeks 2-3° C and 85-90 per cent relative humidity, while firm fruits at 3-5° C and at relavive humidity of 85-90 per cent can be stored for as long as eight weeks.

QUESTIONS

1. Sapota is an important dryland horticulture crop. Justify the statement.
2. List the various methods of propagation employed to propagate sapota, and explain along with their merits and demerits.
3. Give a note on the harvesting and post harvest handling of sapota.
4. Differeatiate between:
   i. Effect of extreme temperatures on growth and fruits development.
   ii. Growth habits of layers and grafts.
   iii. Training and pruing.
   iv. Flowering and fruiting.
5. Write short notes on:
   i. *DSH-1 hybrid*
   ii. *Kalipatil variety*
   iii. *Cricket Ball variety*
   iv. Intercropping in sapota

CHAPTER 10

Guava

Introduction

Guava (*Psidium guajava* L) is native of tropical America and was introduced into India by the Portugese in the 17th century. Guava is cultivated in more than 50 countries of the world but it has attained commercial importance manily in India, Egypt, South Africa, Brazil, Columbia, West Indies, Hawaii and the USA (Florida). It has adapted so well in India, that people consider it as native of India and the guavas grown in Allahabad are considered to be the best in the world.

Guava belongs to the family Myrtacae. The genus *Psidium* has 150 species. The cultivated guava is *Psidium guajava*. The guava plant grows to a height varying from 3 to 10 metres, branching close to the ground and aften producing suckers from the roots. The stem shows a peeling bark. Older shoots are round, while the young growth is quaadranglar. Leaves are opposite and gland dotted, finely pubescent, with prominent veins below. The flowers are auxiliary, solitary or in 2-3 flowered cymes.

Uses and Nutritive Value

Guava is often called the "Apple of the Tropics". The fruit contains 2-5 times more vitamin C than oranges and is also rich in iron, calcium, phosphorus, riboflavin and thiamin. Varieties differ with regard to their vitamin C content (38.3 mg to 210 mg/100 g of pulp). The white fleshed varieties have higher vitamin C content than the pink fleshed ones. Guavas can be relished fresh or can be processed into a variety of products such as jelly, nectar, puddings and fruit juice. The fruit is also canned in the form of pulp or slices.

Area and Production

Guava is one of the important fruit crops of India, as it is cultivated all over the country on an area of more than 100,000 hectares, Bihar and Uttar Pradesh are the most important states cultivating guava. It is also an important crop of Karnataka, Maharashtra, Gujarat, Bihar and Andhra Pradesh States (Table 10.1). Guava cultivation is gaining importance in dryland horticulture and watershed development programmes.

Climate

Though guava is native of the tropics, and is well adapted to a subtropical

Table 10.1 : Area and Production of Guava in India

State	Area (ha)	Production (t)	Productivity (t/ha)
Bihar	22729	227290	10.00
Uttar Pradesh	18562	124406	6.70
Karnataka	11120	106163	9.55
Mahatashtra	8500	39950	4.70
Madhya Pradesh	7540	151000	20.00
West Bengal	4500	40600	9.02
Haryana	4534	54408	12.00
Andhra Pradesh	4440	53280	12.00
Punjab	3909	38090	9.79
Gujarat	3900	85800	22.00
Tamil Nadu	4120	51500	12.50
Total	102533	1015265	9.90

climate. In fact the highest production of guavas in India is in Uttar Pradesh, which lies in the subtropics. While it is very hardy and can withstand heat and prolonged drought, it is highly susceptible to frost. A cool winter induces heavy fruiting and produces good quality fruits. It requires an annual rainfall of about 1,000 mm spread over from June to September. Very heavy rainfall not only induces luxuriant growh but also produces insipid fruits. In humid climate the fruits become insipid and incidence of pests and diseases like fruit fly and canker become severe. However, during flowering and fruiting very high temperatures cause flower and fruit drop as it can stand summer temperatures only up to 46° C. It can grow from sea level to 1,500 m above MSL. In Uttar Pradesh, its performance has been exceedingly good at around 900 m alitude.

Soil

Guava is not very specific to its soil requirement, provided good drainage is assured. Deep, friable and well drained soils are well suited. It can grow in soils with pH as low as 4-5 and as high as 8.2. Since majority of the feeder roots are located between 0-20 cm depth, a rich top-soil can, produce a better crop.

Varieties

There are several varieties of guava under cultivation in the country. Some of the popular ones are described below:

(i) Allahabad Safeda

This vavety is the most popular variety of Uttar Pradesh and Karnataka. The fruits are yellowish to white in colour, round, and weigh 180 g on an average. They are less seeded and have good keeping quality.

(ii) Sardar (Lucknow-49)

This is a selection from Pune in Maharashtra. The trees are semidwarf. The fruits are roundish ovate in shape, the skin colour is light green, and the fruit is soft seeded with good keeping

quality. It is popular in Maharashtra.

(iii) Chittidar

Chittidar is a tall tree. The fruits are straw yellow in colour, with scattered pinkish red spots. They are medium sized and spherical in shape, with a thin soft skin.

There are many other varieties like *Red flesh, Seedless* and *Matchless.*

Propagation

(i) Sexual Propagation

In the past, most guava plants have been grown from seeds. But in order to have true to type plants of desired quality, only vegetatively propagated plant material should be used.

Seed production is still adopted to raise rootstocks. For this purpose seeds are collected from healthy fruits and sown in well prepared nurseries at a depth of one centmetre. Seeds take 2-3 weeks for germination. Since they have low viability it is better to sow them immediately after extraction. The seedlings will be ready for grafting or budding in about one year.

Several other species of *Psidium* such as *P. cujavillis; P. molle,* and *P. guinese* can be used for rootstocks. Chinese guava (*P. friedrichsthallianum*) is not only resistant to wilt but also to root knot nematodes. Dwarfing occurs when *P. pumillum* is used as rootstock for *Allahabad Safeda.* However, for commercial purposes, guava is grafted on its own rootstock.

(ii) Vegetative Propagation

The most common vegetative method of propagation of guavas is by air layering. Though other methods such as cutting,grafting, budding and stooling are also in vogue.

(a) Air Layering

Shoots of the previous season and growth that have attained a diameter of 1 cm, are selected for air layering. Selected shoots are girdled by removing a ring of bark 2.5 to 3.0 cm wide and 45 to 60 cm away from the tip. The girdled area, after being scrapped wih a knife to remove the cambial cells, is covered wih moist sphagnum moss and wrapped in a polythene film. The ends of the polythene film are tied by means of a thread. In the monsoon season, 30-40 days are required for rooting. Application of IBA at 5,000 ppm to the layers promotes better rooting. Ringing the branches and etiolation and wrapping with black polythene film 6-7 weeks before application of growth regulators give better results.

Roots begin to form in four to five weeks. Wehn the roots grow through the ball of moss and are seen from the outside, the stem below the girdle is severed by giving incisions gradually. The polythene film is then removed and the layer is potted and kept in the shade until new leaves appear. When the new growth is 15-25 cm long the plant can be hardened in full sunlight.

(b) Ground Layering (Stooling)

Three to four year old plants are headed back in March and allowed to produce new shoots. The shoots are ringed and treated with IBAd at 5,000 ppm lanolin paste during June-July. After 10 days, the shoots are earthed up to cover the ringed part. By about September, the rooted shoots can be separated. This method is easy and a plot of 4x5 sq. m.

can yield 300 rooted plants each year. The cost of production of plant material is also much less.

(c) Cutting

Though guava cuttings are hard to root, they can be made to root under mist. Young and succulent shoots can be rooted if treated with NAA and IAA at 100 ppm. Treatment of semihardwood cuttings with IBA at 5,000 ppm as quick dip has been found to induce increased rooting.

(d) Grafting

Though a more labourious, approach grafting gives better success (90%). Top working, adopting veneer grafting method is also successful. For this purpose, scions from terminal growth flushes having a quadrangular stem, with well developed axilary buds, should be selected. Scions about one month old,. 3-5 cm long, having one or two buds, can be used for grafting. The percentage of success is over 80 per cent when grafting is done in June-July.

Planting

June-July is found to be the best time for planting. Grafts or layers are planted at a spacing of 6.0 × 6.0 m. High density planting is becoming common but is has to be accompanied by regular pruning.

The land is prepared by ploughing and harrowing. Before the onset of regular monsoon, pits of 90 cm cube are dug and filled with 25 kg farmyard manure and top-soil. Addition of soil insecticides, like Aldrin or Heptachlor at 100g/pit, is desirable as it minimises the incidence or termites and root grubs.

Grafts are planted in the centre of the pit taking care to see that the graft union remains well above the ground. Planting should be followed by watering. June-July is the ideal period for planting. The side shoots as and when they arise have to be removed from the trunk up to a height of one metre from ground level in the initial years.

Training and Pruning

The guava plants are trained to open centre system or modified open centre system. Crisscrossing of primary branches should not be allowed during the initial years of planting. In the case of spreading varieties, like Sardar guava, primary branches are allowed from a height of at least 75 cm from ground level.

Guava is rarely pruned, but light annual pruing after harvesting to promote vegetative growth and flowering is desirable. Pruning is also used to change the crop yielding pattern. Pruning druing April-May will help in increasing the winter crop yields. Pruning the dry and dead wood during April is also good as pruned trees give larger fruits and the fruits ripen early. Wherever, hedge row planting is done annual pruning is necessary.

Intercropping

As intercrops, vegetables or other leguminous crops can be grown during the first 5-6 years if irrigation is available. Papaya or pineapple can also be grown as mixed crops wherever they grow well and are in demand.

Manuring and Fertilisation

Guava flowers and fruits on the current season's growth. Proper nutrition encourages vegetative growth and consequently the yield. The schedule for nutrient (fertiliser) application is as below:

Age of plant	*FYM kg/ plant*	*Nutrient g/plant/year*		
		N	P_2O_5	K_2O
1-3 years	25	50	25	75
4-6 years	25	100	40	75
7-10 years	50	200	80	150
More than 11 yeras	50	300	120	150

Guava leaves sometimes show bronzing which is mostly due to micronutrient deficiencies. Interveinal chlorosis of younger leaves, resulting in small leaves is associated with zinc deficiency. Zinc sulphate (0.3 per cent) and boric acid (0.45 per cent) spray before flowering has been found to correct the deficiencies.

Irrigation

Guava being a hardy crop, requires less irrigation compared to other fruit crops. In the first two years, irrigation is given regularly and later only during the hot weather period. In regions where the average annual rainfall is 400 to 500 mm, the guava trees can do well with 8-10 irrigations. This would mean one irrigation every 20 days in summer and every 30 days in winter. Irrigation depends to a great extent on the regulation of crop desired. In South India, if irirgation is given, the guava bears almost throughout the year. However, in North India, there are two peak seasons for crop production, and crop regulation is manipulated by regulating the water supply.

Flowering and Fruiting

In guava flowers, both self as well as cross pollination occur. The flowers are pollinated by honey bees and other insects. Natural cross pollination occurs to the xtent of 35 per cent. The flowering period varies from 25 to 45 days. Usually guava flowers thrice thrice during the year in February (Rainy season crop), June-July (Summer crop) and October (Winter crop).

Only 34-50 per cent fruits are carried to maturity, though the initial set may be as high as 80-85 per cent. In seedless varieties it is as low as 6 per cent. To improve fruits set, GA 200 ppm may be sprayed. Fruits take 105-140 days from fruit set to maturity. Fruit drop, if any, can be controlled by spraying Planofix at 40 ppm during initial fruit set.

Plant Protection

(a) Major Insects and Their Control

(i) Fruit-fly (*Chaetodacus sp*)

During the monsoon, after the adults lay eggs on the fruits, the maggots bore into the fruits causing fruit drop. The February flowering crop is severely affected by this insect.

For effective control of this insect, fallen and affected fruits are collected and burnt. Traps containing 1 ml methyla eugenol, and 2 ml Malathion + 100 g jaggery per litre of water are used to trap male fruit-flies.

(ii) Mealy Bugs (*Cryptoloms spp*)

Mealy boys suck the sap from the tender twigs and leaves.

The soil at the base is treated with Aldrin or Thimet. This prevents climbing of nymphs from the ground. Malathion 20 ml/10 litres of water is sprayed to control adult mealy bugs. Mealy bugs also encourage sooty mould.

(iii) Scale Insects (Pulvinaria psidii)

This is also a sucking pest. It encourages sooty movld by secreting honey dew. Spraying Carbarly 40 g or Dimethoate 10 ml in 10 lites water can control this pest.

(iv) Tea Mosquito (*Helopeltis antonii*)

This pest causes guava canker by puncturing the skin while sucking the sap.

It can be controlled by spraying 20 ml Endosulfan in 10 litres of water at three week intervals, during flowering and fruiting.

(v) Fruit Sucking Moth (*Ophidars spp*)

Nigh flying moths suck the fruits. The affected fruits fall off. It can be controlled by spraying 0.1% Lebacid.

(b) Major Diseases and Their Control

(i) Fruit Canker (*Pestaotia psidii*)

Conspicuous raised lesions appear on the fruit. It is likely that tea moquitoes transmit this disease. A fungicidal spray, in combination with an insecticide, is effective in controlling this disease.

(ii) Anthracnose (*Gloeosporium psidii*)

This is a serious disease in some areas. The shoots, leaves and fruits are affected and die back sets in, Dithane Z-78, or Difolation. 20 g in 10 litres of water can control this disease.

(c) Disorders

(i) Bronzing

The leaves initially develop purple to red specks scattered all over the leaf surface, which later coalesce giving rise to distinct bronze colouration. In advanced stages, the tree shows stunted growth and partial defoliation of twigs. The fruits from affected plants show brown coloured pateches on the skin. The yield gets drastically reduced. Plants growting in soils defirient in nitrogen, organic carbon, available phophorous and potassium, zinc and low in soil pH exhibit bronzing. Spraying 0.5 per cent diammonium phosphate + zinc sulphate at weekly intervals for two m onths before flowering and fruiting can reduce bronzing.

(ii) Guava Wilt

This is the most serious disease in North and Western India and is found in alkaline soils with poor drainage. It is reported to be caused by *Fusarium* fungus. In U.P. *Fusarium oxysporium* and in Bengal *Fusarium solanii* and also *Rhizoctonixa bataticola and psidii* are found. It is more rampant during the rainy season. Casual organism is not well understood. On the affected plant whole limbs first dry up. The tree eventually dies and there is no remedy except avoiding waterlogged conditions and alkaline soils.

Maturity Standard and Harvesting the Post-Harvest Handling

Guava plants start bearing from 3-4 years after planting and economic yields can be obtained from 5-6 years onwards. Guava fruits ripen in five months after flowering and they are harvested when their colour changes to a yellowish green. Highest quality is obtained in tree ripe fruits but they are highly perishable and therefore, for a distant maket they should be harvested just at colour break. For jelly hard mature fruits are preferred. Individual fruits are picked by hand when light yellow in colour. Mature half ripe fruits are most liked for consumption. Fruits should be plucked with leafy shoot and need to be graded and packed in bamboo baskets for marketing.

Yield

Fruit yield varies depending upon the varieties. On an average a 10 year old tree may yield about 1,000-1,500 fruits per year. Average productivity is about 10 tonnes per hectare.

Storage

The fruits, being perishable, should be marketed immediately. However, they can also be stored in cold storage at 8.5-14° C for 4 weeks. Application of MH (Maleic hydrazide) at 500 to 1,000 ppm and GA at 100-200 ppm is found to retard ripening and loss in weight. Cold storage of guava is not recommended, as the fruits tend to lose their lustre and deteriorate quickly when they are removed from storage.

Packing

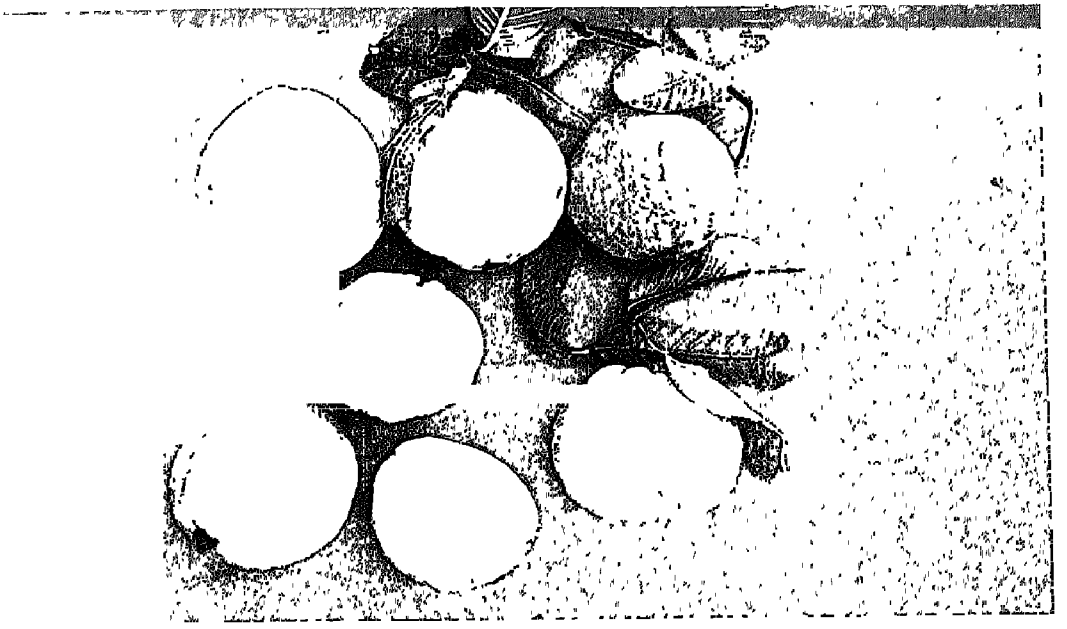
For distant transport, fruits are packed in bamboo baskets. They can also be packed in perforated polythene bags.

QUESTIONS

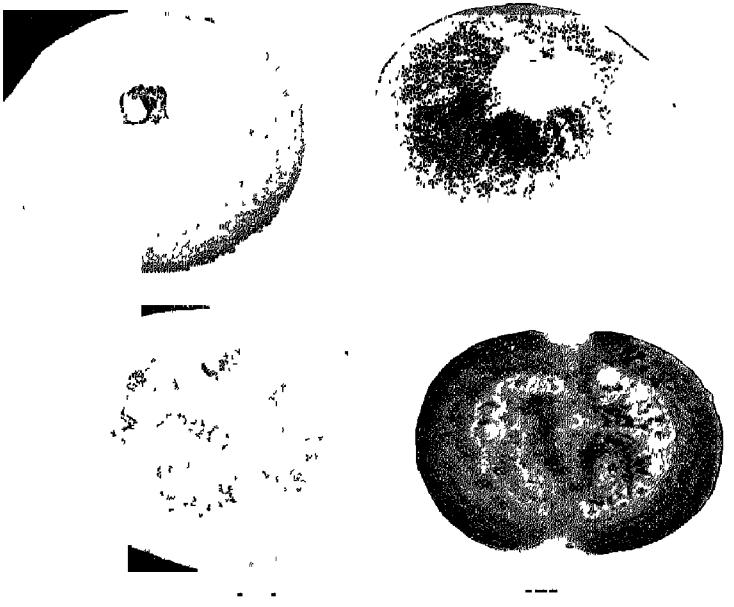
1. Guava is called 'Tropical Apple' or "Poor man's Apple". Justify the statement.
2. Explain the different vegetative methods employed to propagate guava.
3. Give a note on the types of rootstocks for guava and their utilisation.
4. Discuss flowering and fruiting, and suggest possible measures to improve the fruits set in guava.
5. Write short notes on:

   a. Bronzing b. Storage c. Tea Mosqutio d. Guava wilt.

GUAVA VARIEITIES



Sardar



Red Flesh

PAPAYA VARIETIES

Coorg Honey Dew

Washington

Solo

Waimanalo

CHAPTER 11

Papaya

Introduction

Papaya (*Carica papaya* L) is native to tropical America somewhere in the region between southern Mexico and Nicaragua, and was introduced to India during the 16th century. In India, it is becoming increasingly important because of the ease of cultivation, quick returns, adaptability to diverse soil and climatic conditions and high nutrivive value. The papaya is mainly grown in Brazil, Mexico, Hawaii, Peru, the Philippines and India. In India the papaya is grown on an area of 45,239 hectares (Table 11.1).

Botany

Papaya belongs to the family Caricanceae. Apart form *Carica papaya*, other species of genera *Carica* are *C. goudotiana*, *C. candamarcensis*, *C. cauliflorus*, *C. conoica*, *C. pubescence*, *C. microcarpa*, and *C. spherocarpa*. Of these, only *C. papaya* is edible, and the other species are important in the breeding programmes to develop resistance to diseases and to induce cold hardiness.

The papaya trunk rarely branches. The trunk is hollow with a cavity between nodes, the sap-milky, leaves-alternate, palmately lobed or rarely entire, large, long petioled, and the roots, extensive and dense.

The economic lifespan is 2-3 years. The papaya plant is normally dioecious, bearing male flowers on one plant and female on another. Of these, the pistilla (female) flowers alone produce fruits. The hermaphrodite plants have perfect flowers (mdale and female parts in the same flower) and do not require cross pollination.

The fruits are borne on the trunk at the base of the leaves. It is variable in shape, size and quality. The skin is smooth and green in colour, turning yellow when ripe. The flesh is yellow to orange in colour and resembles melon in appearance and consistency. A large number of dark brown small seeds, with translucent mucilaginous covering, are attached to the wall of the central cavity.

Uses and Nutritive Value

The ripe papaya fruit is very refreshing, high in nutritive value and is prized for its medicinal properities. It is a rich source of vitamins A and C. On an

average, 100 g of edible portion of ripe papaya contains 2500 Internatinal Units of vitamin A, 57 mg of ascobic acid (vitamin C) and 33 Sherman units of vitamin B.

Table 11.1 : Area and Production of Papaya in India

State	Area (ha)	Production (t)	Productivity (t/ha)
Andhra Pradesh	274	3,288	12.00
Arunachal Pradesh	554	1,004	1.82
Assam	4,882	75,058	15.37
Gujarat	3,400	1,70,000	50.00
Karnataka	4,560	1,94,562	42.67
Kerala	12,685	55,999	4,42
Madhya Pradesh	924	23,000	28.89
Manipur	310	1,450	4.68
Meghalaya	446	3,698	8.29
Mizoram	136	552	4.06
Nagaland	5	85	17.00
Orissa	10,305	1,15,000	11.15
Rajasthan	442	2,210	5.00
Sikkim	200	303	1.52
Uttar Pradesh (plains)	536	16,143	30 12
West Bengal	5,300	1,40,690	26.55
Andaman and Nicobar	203	965	4.75
Delhi	11	110	10.00
Lakshadweep	40	185	4.63
Pondicherry	26	1,040	40.00
Total	45,239	8,05,342	17.80

It improves digestion and is said to cure chronic constipation, piles and enlarged liver and spleen. It is also rich in minerals like calcium, phosphorus and iron.

Papain is a valuable protecolytic enzyme extensively used as a digestive aid and in the treatment of ulcer and diphtheria. Papain finds industrial use in the manufacture of pre-shrinking of wool and degrimming of natural silk and rayon, tenderisation of meat, clarfication of beer and in the preparation of chewing gums.

Climate

Papaya thrives well in tropical as well in mild subtropical climate. It is susceptible to frost. It is best grown in a temperature range of 22 to 36° C. However, 35° C day and 25° C night temperatures are most suitable. It also thrives well in regions where the temperature ranges from 37° C-40° C in summer, and in winter where temperatures do not frequently go below 14° C. A dry climate at the time of ripening is important. The flavour of the fruit is correlated with temperature at which the fruit matures. Low temperature mars

the flavour of the fruit and makes it insipid. Papaya can be grown up to an elevation of 1,000 m from sea level.

Soils

Papaya is not exacting about the soil type, provided it is well drained. It prefers rich soil but can be grown on comparatively poor soils also with the help of heavy manuring and watering. Papaya is best grown on rich loams of uniform texture and depth of about two metres. Medium black and alluvial soils are also suitable. Deep clayey, calcareous and rocky soils are not suitable. Papaya does not tolerate stagnation of water around the trunk, Nor will its roots thrive in waterlogged soil. It does well in soils having a pH range of 6-7.

Varieties

The following are imprtant commercial varieties of papaya grown in different parts of the country. However, since it is propagated by seeds, purity of varieties has to be maintained carefully.

(i) *Honey Dew*

A semi tall variety, dioecious in nature bears fruits low on the trunk and heavily. The fruits are elongated, the pulp is extra fine, sweet and it has a very agreeable flavour. It is very high yielding and has few seeds. This variety is popular all over India and is known as "*Madhu Bindu*".

(ii) *Coorg Honeydew*

This is a selection from the Honey Dew variety developed at the Central Horticultural Research, Institute, Chethalli. This variety produces no male plants. The plants are either hermaphrodite or female. Fruits borne on female plants are almost seedless. Its fruits are of excellent quality.

(iii) Washington

The plants are vigorous, the stem has purple rings at the nodes, petiole dark purple, the flowers deep yellow, fruits large round or ovate in shape and borne in large numbers, the seeds few and the pulp sweet with an agreeable flavour. Male and female plants are separate.

(iv) Solo

This is one of the best known of gynodioecious varieties from Hawaii. Fruits are small, deeply ribbed, pyriform and with yellowish orange pulp. The keeping quality is good. It is an ideal variety for the kitchen garden owing to its small stature ans small sized fruits. Some of the recently raised improved varieties from Pusa (Bihar) are as follows:
(i) *Pusa delicious:* A gynodioecious line with medium sized fruits (1.5 kg) and high yield.
(ii) *Pusa Majesty:* Another gynodioecious variety. It has firm flesh and can withstand long distance transport. The plants seem to be resistant to virus diseases.
(iii) *Pusa Giant:* The plants are very vigorous dioecious. Fruit weight ranges from 2 to 3.5 kg.
(iv) *Pusa Dwarf:* The plants are dwarf and bear fruits 45 cm from the ground. They are dioecious and medium yielders. The fruit weight is 1 to 1.5 kg.
Improved strains released from Tamil Nadu Agriculture University, Combatore are as follows:

(i) *CO-1:* Developed by sibmating the 'Ranchi' variety for a period of eight years. The fruit is spherical, greenish yellow with a slight nipple, ridged in the apex, and having orange yellow flesh.
(ii) *CO-2:* A dioecious, semidwarf selection with long fruits, weighing 1.5 kg each. It is suitable for table and papain producion. It yields 5-6 g of papain per fruit.
(iii) *CO-3:* A hybrid derivative between gynodioecious. The pulp is attractively red coloured and is good for table purpose.
(iv) *CO-4:* Another hybrid derivative between *CO-1* and *Washington.* The plants are dioecious with large fruits weighing up to 5 kg.
(v) *CO-5:* A selection from *Washington.* The plants are exclusively suitable for papain extraction. They yield about 75-80 fruits in two years. The dry papain yield is more than 1500 kg/ha or 14-15 g/fruit, which is 2-3 times more than that of *CO-2* variety.
(vi) *CO-6:* A selection from *Pusa Majesty.* It starts yielding 80-100 fruits in 230 days. It is also a high papain yielder and prodecs about 890 kg of dry papain per hectare or 7.5-8 g per fruit.

Propagation

Papaya is propagated entirely from seeds sown in nursery beds or in polythene bags. Seed viability is lost in about 45 days, but can be extended to 9 months by storing in sealed bottles. Raised seed beds of 8 m x 1.25 m are made 10-15 cm above the ground level with the addition of 10-15 kg of farmyard manure and ½ kg of 15:15:15 NPK mixture per bed. It is then mixed well with the soil and beds drenched with Cerasan wet (2g/1 of water) solution. The seeds are sown 2-3 cm deep in 15 cm rows at 5 cm apart. Germination is enhanced by soaking the seeds in cow's urine overnight. About 250 g of fresh seeds are enough to raise seedlings sufficient for one hectare. The seedlings can be transplanted in about 60 days when they attain a height of 15-20 cm. Sowing of seeds during March-April and provision of shade to young seedlings during summer is important for their optimum growth.

Seed germination will be early and better if sown in seed pans and covered in the night with another seed pan, rather than sowing them in seedbeds. Seedlings of 10-15 days old are transplanted in perforated polythene bags of 22 cm x 14 cm size of 150 gauge thickness filled with mixture of farmyard manure, soil and sand in equal proportions. Papaya seedlings raised in polythene bags can stand transplanting better than those raised in seedbeds. Normally two seeds are sown in each bag and only one sedling is retained after germination.

Planting

Papaya is planted at spacing of 1.8 x 1.8 m in pits of 50 x 50 x 50 cm size. These pits are dug in advance and left exposed to the sun and filled back with top-soil and farmyard manure (50:50). In the case of gynodioecious varieties, only one seedling is planted. In case of dioecious verieties two seedlings per pit should be planted, which are later thinned to one at the time of flowering. Seedlings must be staked, shaded and watered regularly till they are well established.

Interculture and Intercropping

Different vegetables can be profitably grown as intercrops for about six months from planting of papaya seedlings. Papaya plantations can be kept weed-free by the application of weedicides like Fluchloralin, or Butchlor at 2.0 kg/ha. Post emergent herbicide-glyophosate has also been found as effective as Fluchloralin and has given ample control of all dicots for nearly five to six months.

In light soils, it is desirable to mound soil around the trunk of plants to enable them to withstand strong winds and to prevent them from falling.

Manure and Fertilisers

Fertilisers at the rate of 250 g N, 250 g P and 500k g K per plant per year should be applied in 6 split doses at 2 months interval. Each application should comprise of 200 g of ammonium sulphate or 90 g of urea, 250 g single super phosphate and 50 g muriate of potash per plant. The fertiliser mixture should be applied in ring in the basin and mixed well with the soil.

Fertiliser Schedule for *Solo* and Other Varieties of Payaya

(kg)	*Per plant*	*Per hectare*	
	(g)	*Solo*	*Other varieties*
N	250	625	525
P	250	625	425
K	250	1250	850

Irrigation

Papaya should be irrigated once in 8 to 10 days in winter, and once in six days in summer in medium soils. Ring system of irrigation is considered better than bed or basin system because the ring system prevents irrigaion water from coming in direct contact with the stem, thus preventing collar rot disease.

Flowering and Fruiting

The plant growth and flowering is simultaneous in papaya. In the axil of each unfolding leaf, there is a flower, and thus a potential fruit. Papaya must be kept growing vigorously in order to maintnain a continuous supply of fruits.

Fruit Thinning

In papaya, several fruits are set in a cluster instead of single fruit at each node. It is desirable to thin the fruits clusters, leaving not more than one or two fruits at each leaf or node. The operation is known as thinning and should be performed regularly after fruit set in varieties where several fruits are borne per cluster.

Plant Protection

(a) Major Pests and Their Control

(i) Mites

The red spider mites suck the sap from the central surface of leaves. The infested leaves are removed and burnt and the plants are sprayed with 0.04 per cent Dicofol or 0.06 per cent Dimethoate at 15 days interval. It can also be controlled by spraying wettable sulphur.

(ii) Aphids

Aphids suck sap from the leaves and

also transmit mosaic virus disease.

Removal of mosaic affected plants, destruction of weeds which are alternate hosts to aphids, prophylactic spray of 0.03 per cent Dimethoate or 0.025 per cent Methyldemeton, or 0.04 per cent Monocrotophos, can effectively control aphids and also mosaic virus disease.

(iii) White Fly

This transmits leaf curl virus and its activity is more in the dry season. Control measures taken for aphids will also control white flies.

(b) Major Diseases and Their Control

(i) Damping Off

Dmping off disease causes rotting of seedlings in the nursery. This can be prevented by sterilisisng the soil of the seedbed with 2.5 per cent Formaldehyde solution. 15 days before sowing of seeds. Seed dressing with Ceresan dry (1g/ 400g of seed) also gives adequete control.

(ii) Collar Rot or Stem Rot (*Pythium aphenidermateum*)

Waterlogging and poor drainage causes this malady. Scraping the affected parts and painting with Bordeaux paste, and spraying of Boardeaux mixture (5:5:50) controls the disease.

Papaya mosaic, leaf curl, ring spot, distortion and papaya leaf reduction are the virus diseases affecting papaya. Removal of the affected trees immediately burning them and periodical spraying with systemic insecticides will keep viral diseases under control. Two species of *Carica* i.e. *C. cauliflora* and *C. candamarcensis* have been reported to be resistant to mosaic virus and they are best used in breeding to develop resistant varieties.

Harvesting and Yield

In about 5-6 months from transplanting, these seedlings start flowering and setting fruits. Harvesting of ripe fruits starts in about a year (10-12 months) from the time the seedlings are transplanted in the main field.

The number of fruits harvested per tree varies from 40-150 in a year depending upon soil, climate, variety and cultivation practices. Although papaya plants bear flowers and fruits continuously for many years, it is not considered economiocal to retain the plantation after three years.

Fruits showing streaks of yellow colour are harvested. The fruits are packed in baskets for the market. The individual fruit should be wrapped in tissue paper or newspaper, and the space between the fruits should be stuffed with straw or paper cuttings, to protect the fruits from damage in transit.

On an average one hectare of papaya plantation may yield about 70-80 tonnes of frutis.

Extraction of Papain

Papain is extracted from the immature fruits which are about 90 days old. The surface of fruits are incised longitudinally to a depth of 2-3 mm with a razor or bamboo splinter. Four cuts are given each time in the morning and this process is known as "lancing". Four such lancings are possible at an interval of 3 days. The latex is scrapped out with the help of a spatula and dried in the sun or in an oven at 50-55° C. The dried latex is then powdered and packed in polythene or

butter paper bags and stored in air tight containers. Ethephon at 200 ppm aplied as whole plant spray on *Coorg Honey Dew* was found to increase the papain yield by 145 per cent. The fruits do not suffer much in quality after extraction of papain.

It is possible to obtain a crude papain yield of about 500-750 g per plant per year, depending upon the variety used.

Papaya Products

Several products are prepared from papaya, of which the important ones are:

(i) Papaya jam

Jam is prepared with equal quantity of pulp and sugar i.e. one kg of pulp and one kg of sugar with 5 g of citric acid.

(ii) Canned Slices

Canned slices are prepared by using 20° Birx sugar syrup with 0.3 per cent citric acid. for canning papaya slices cm width of 2.5 to 4.0 should be used.

(iii) Tuty Fruity

Immature papayas are peeled and pieces are immersed in 70° Brix sugar for about 48-60 hours with permitted colours.

(iv) Papaya Beverage

This is a ftuit juice usually with 60° Brix and preserved with potassium metabisulphite. It is considerably altered in composition by diluting it in 1:3 ratio before it is served as a drink.

QUESTIONS

1. Discuss be the nursery practices followed to propagate papaya.
2. What is papain? Give its uses and method of extraction on a commercial scale.
3. State the problems in papaya cultivation and discuss the possible means to overcome them.
4. Explain the following :
   a. Gynodioecious papaya
   b. Fruit thinning
   c. Papain extraction
5. Write short notes on :
   a. Collar rot
   b. *Coorg Honey Dew* variety
   c. Papaya jam
   d. *Washington*
   e. *Sholo* variety.

CHAPTER 12

Pineapple

Introduction

Pineapple (*Ananas comosus*) is an imprtant fruit crop belonging to the family Bromiliaceae. The fruit is a good source of vitamin. A and B and fairly rich in vitamin C and minerals like calcium, magnesium and iron. It is also a source of bromelin, a protein digesting enzyme. The fruit has the following composition:

Constitutents	*Per cent*
Moisture	85.00
Sugar	13.00
Protein	0.06
Mineral matter	0.05
Vitamin A (Carotene in i.u. /100g)	601.00
Vitamin C (mg/100g)	63.00
Calcium	0.02
Phosphorus	0.01
Iron	0.09
Acids	0.06
Riboflavin (mg/100g)	120.00

The fruit waste after juice extraction is a good cattle feed. The other by-products are alcohol, calcium citrate, citricacid and vinegar. Preparation of oxalic acid, pineapple gum and pineapple flavour is also possible. The fruits can be processed into canned slices, tid-bits, juice, sqash, jam and mixed jam. The fruits core is used for preparation of a fine fabric called "Pine" in, the Philippines.

Origin and Distribution

Pineapple is believed to have originated in Brazil, from where it has spread to other tropical parts of the world. The important poineapple growing countries are Hawaiian Islands, Queensland, Malaysia, South Africa, Sri Lanka, Singapore and India.

Its cultivation is confined to high rainfall and humid coastal regions in peninsular India, and to the hilly areas of the North-Eastern region of the country. It is being grown commercially in the interior plains with medium rainfall and supplementary protective irrigation. The area under pineapple in India is estimated to be around 83,490 hectares with an estimated production of 6,43,100 tonnes. It is grown largely in the states of N.E. region, W.Bengal, Kerala, Tamil Nadu, Karnataka.

Climate

It is native to the tropical region and has spread to subtropical areas also. The optimum temperature range for successful pineapple cultivation is between 22°C to 32°C. The leaves and roots grow best at 32°C and 29°C, respectively and their growth practically ceases below 20°C and above 36°C. It can be grown upto an elevation of 1,525 m above sea level, if the areas are free from frost. Although optimum annual rainfall for commercial pineaspple production ranges from 1,000 to 15,000 mm, it shows a remarkable ability to grow and produce crops under a wide range of rainfall conditions. In areas where the rainfall is less, supplementary protective irrigation and growing of shade crops are necessary during the dry season. The optimum humidity requirement ranges between 75-78 per cent. Sunshine also plays an important role in plant growth and quality of fruits.

Soils

The pineapple plant comes up well in any type of soil, except on heavy clay soil. However, sandy loam soils are best for its cultivation. The soil should be 45-60 cm in depth without a hard pan or stones. Low lying area should be avoided. The plant prefer slightly acidic soil with a pH range of 5 to 6.

Varieties

There are two important varieties of pineapple. Their description is as follows.

(i) *Kew*

This variety belongs to the 'Cayenne' group and is extensively grown in India. It is considered to be the best variety for canning since it is of good quality and has broad and shallow eyes on the fruit. The fruits are of large size (1.5 to 2.5 kg) oblong in shape and tapering slightly towards the crown. The ripe fruits are yellow in colour, juicy, with a good aroma. The flesh is firm, pulp light yellow in colour and is almost fibreless. The margin of the leaf has a small sector of spines just behind the tip. It is a late variety.

(ii) *Queen*

The plant, fruit and shoots are smaller than that of *Kew*. The fruits weigh 0.9 to 1.3 kg, and are cylindrical in shape. The flesh is firm and golden yellow in colour. The fruit is less juicy than *Kew*, crisp with a pleasent aroma and flavour. the leaves are brownish red, shorter and very jspiny. The eyes are small and deep requiring a deep cut when removing skin. It is an early variety.

Propagation

Suckers, slips and crowns are the three important parts used for planting. Suckers arise from the axils of the leavs first below the ground level, and the slips are formed on the fruit stalk below the fruit. Suckers and slips are usually preferred for planting, since they flower comparatively earlier than the crowns. Suckers produce the first crop in 15-18 months after planting, while the slips take 20-22 months. Crowns take more than 24 months. Usually planting is done during the monsoon season to take advantage of soil moisture. Where irrigation facilities are available, planting can, however, be taken up all round 'the year' to enable harvesting spread over a longer period during the year.

Planting

The land selected should be ploughed deep, or dug to a depth of 30-40 cm till a fine tilth is obtained. For soils low in organic matter compost or farmyard manure at the rate of 10-15 tonnes per hectare is applied and mixed in the trenches at planting. The best planting materials are ground suckers and slips. The root primordia are present in the basal portion of the planting materials which are covered by scaly leaves. After removal of these scaly leaves, planting materials should be treated with Ekalux (0.05 per cent) and Dithane Z-78 (0.03 per cent) or Difolatan (0.04 per cent) to protect against mealy bugs and heart rot, respectively. Too large suckers or slips are not good for planting. Planting material should not be heaped but arranged up-side-down under the shade.

The double row method of planting is ideal. For this purpose the field is laid out in trenches alternating with mounds. In hilly areas, the trenches are to be made across the slope. The depth of the trench should be 22 to 30 cm.

In each trench, two shallow furrows of about 10-15 cm depth, and 15 cm from the edge of the trench are made with a pick-axe, or two rows of 10-15 cm deep holes are made with a crow bar. The plants are planted diagonally so that no two plants are exactly opposite to each other. Care must be taken to prevent the soil from getting into the heart of the growing plant while planting.

The spacing for accommodation of different plant populations per hectare by double row method is as follows :

Distance (cm)			*Plant population ha*
Plant to Plant	*Row to row*	*Trench to trench*	
30.0	60	90	43,500
25.0	60	90	53,000
33.5	45	90	63,500

As aganist 60.000 to 62,000 plants per hectare in the Philippines, the planting density commonly followed in Indian Institute of Horticultural Research, Hesserghatta, Bangalore, has shown that a population density ranging from 53,000 to 63,500 plants per hectare could be easily adopted, yielding 85 to 105 tonnes of fruits per hectare without adversely affecting the size, quality and canning recovery of the fruits. Therefore, high planting density gives more profits, apart from the other advantages like less weed infestation, protection from sunburn, increased production of suckers and slips per unit area and non-lodging of plants. In wider spcing, 20-25 per cent of the fruts get sunburnt. Close planting also helps in moisture conservation of soil as the transpiration loss is much less when compared to evaporaion from the soil. It has also been found possible to take at least two ratoon crops with high density planting.

Manures and Fertilisers

For obtaining higher yields, apart from 30 tonnes of farmyard manure, a fertiliser dose of 350 kg of N, 130 kg of P_2O_5 and 438 kg of K_2O per hectare is recommended.

Investigations conducted have shown that a dose of 12 g N per plant is ideal under irrigated conditions, whereas under rain fed condition, a dose of 16 g N per plant was found necessary for getting a higher yield. Potash at the rate of 12 g/plant is recommended for irrigated as well as rain fed crops.

It is advisable to apply nitrogen in six split doses, starting two months after planting at bi-monthly intervals in such a way that the last dose falls within a year after planting. Application of fertiliser under rain fed condition is to be done when enough moisture is available.

Foliar application of nitrogen is practised in large scale plantations and part of the nitrogen is sprayed in the form of foliar spray of urea (2-4 per cent).

Deficiency Disorders

Iron, zinc and copper deficiencies are common in pineapple.

Iron: The typical symptom of iron deficiency is chlorosis, the disappearance of the green leaf colouring substances, which also occurs due to mnitrogen deficiency. Chlorosis caused by nitrogen deficiency occurs in the older leaves while iron deficiency is exhibited in younger leaves first. Spraying the affected plants with iron sulphate ($FeSO_4$ at 3 per cent) is ideal.

Zinc: Zinc deficiency is often found on peat and sandy soils, which are badly drained and strongly acidic. The curling and twisting of the heart leaves is also common. Later, the leaves become narrow, acquire a light green to yellow colour and their surface is covered with a thick layer of wax. Foliar application of 1 per cent zinc sulphate solution is recommended to correct the zinc deficiency, About 20 litres of 1 per cent zinc sulphate solution is sufficient for one hectare of area.

Copper: Crook-neck symptom is common in copper deficient plants. Copper sulphate cannot be applied as a spray to the leaves since it causes severe scorching. Spraying the same on the ground near the plant with 30 to 50 ml of 1.5 to 2.0 per cent solution has been found to be a satisfactory cure.

Flowering and Fruiting

Irregular flowering behaviours of pineapple is one of its major drawbacks. Naphthalene acetic acid (NAA) in the form of 'Planofix' at 10-20 ppm (1 ml of plan of × in 4.5 or 9 litres of water) induces good flowring in pineapple. The treatment consists of applying 50 ml of the solution into the heart (centre) of each plant.

Ethrel or Ethephon at 100 ppm could also be used to induce flowering. The concentration of Ethephon (100 ppm) could be reduced to 25 ppm by combining it with 2 per cent urea and 0.04 per cent sodium carbonate. Application of growth regulators to induce flowering has to be done when plants have attained 35-40 functional leaves and on a clear sunny day. One year old plants are optimum to receive the growth regulator treatment.

There is possibility of staggering the harvest almost throughout the year by (i) planting the material at regular intervals throughout the year, (ii) using suckers and slips of different sizes, and the use of growth regulators. This is, however, possible only under irrigated conditions.

Weed control

The major factor which contributes to

the high cost of production in pineapple is the manual weeding which accounts for nearly 40 per cent of the total cost. Weeds could be effectively controlled by spracying a combination of Bromacil and Diuron at the rate of 2 kg a.i./ha each as pre-emergent spray to weeds and as soon as the pineapple suckers are planted. One thousand litres of water (containing 2 kg a/i of each herbicide) per hectare would be sufficient to give satisfafctory spray coverage, While spracying weedicides as far as possible, keep the spray nozzle facing toward the soil, avoiding the pineapple plants and to avoid wastage of the chemical. Irrigate 2-3 days after the spray of the herbicides. Bromacil and Diuron work very effectively in sandy and clay loam soils. In areas where the density of weed flora is heavy, the effet of herbicides may breakdown after one year and a second spray consisting of half the concentration of the first spray may have to be given.

Plant Protection

Major Insect Pests and Diseases and their Control

(i) Mealy Bugs

Mealy bugs (*Dysmicoccus grevipes)* cause wilt and eventual death of plants. Thimet at 17.5 kg pert hectare gives best control upto 100 days. Control of mealy bugs can be achieved by treating the soil either with 27.5 kg/ha of Chlorodane or Heptachlor at 22.55 kg/ha to kill the attendant ants.

(ii) Heart Rot

This disease is caused by *Phytophtohora parasitica*. It can be controlled by good drainage and dipping the planting materials in 0.4% Difolatan at the time of planting.

Harvesting, Yield and Post Harvest Handing

The plant generally gives out the inflorescence in 12-13 months after planting. The fruits take 4½ to 5½ months to mature and ripe. With a slight colour change at the base of developing fruit, it may be harvested for canning purpose. But for table purpose the fruit should be retained till it develops a golden yellow colour. The yield for a population density of 43,500 plants per hectare is about 65 tonnes and for 53,000 to 63,500 plants, it is 80 to 100 tonnes. Yields of the first and second ratoon crops range between 50 and 60 per cent of the first crop. Pineapple, fruits are consumed as dessert fruit and a good part of the produce is used for processing.

For successful marketing, the fruits are to be graded on the basis of size, shape, maturity and freedom from blemishes. The crowns should be trimmed to less than 10 cm and stalk end to 5-7 cm. The fruits so prepared are wrapped in paddy straw individually and arranged in layers in bamboo or wooden containers with straw as cushioning material in the interspaces of the fruits and transported to the markets by road. They are found to remain in good condition for a period of 7 days.

Pineapple fruits can also be stored for a longer period by treatment with NAA and GA_3 at 500 and 100 ppm respectively. The treated fruits remain in good marketable conditions even up to 40 days while the nontreated ones can stand well only for 12-15 days at room temperature.

Aftercare of the Ratoon Crop

After the harvest of the fruits, desuckeing should be done immediately, leaving only one sucker on the mother plant and all the others should be removed. Plants should be supplied with fertilisers and earthed up so that they can have a good anchorage for the ratoon crop. Weeds may be controlled by using preemergent weedicides at half or full dose as required, depending upon the density of weeds.

QUESTIONS

1. List the important pineapple growing countries in the world and discuss its climatic requirements.
2. How do we propagate pineapple? Give the various methods of planting followed in pineapple cultivation along with their advantages and disadvantages.
3. Discuss weed management in pineapple plantations.
4. Explain the use of growth regulators to regulate flowering in pineapple.
5. Differentiate the following.
   a. 'Kew' and 'Queen' b. Suckers and crown c. Slips and suckers
6. Write short notes on :
   a. Heart rot b Crook neck c. Iron deficienry sympton

CHAPTER 13

Litchi

Introduction

Litchi (*Litchi chinensis* Sonn) is a delicious juicy fruit of excellent quality. India ranks second in world production. The litchi usually comes in the market in May and early June when very few fruits are available in India.

Origin and Distribution

Litchi is indigenous to southern China particulary the provinces of Kwangtung and Fukien. From China, litchi reached the West Indies by 1775, South Africa in 1869, Hawali Islands by 1873 and Florida in 1883, Other countries where it has spread are Vietnam, Indonesia, southern Japan, Formosa, Australia, New Zealand, Brazil, etc. Litchi reached India through Myanmar and was first introduced in Bengal. During the last 200 years, its cultivation has spread to other parts of India particularly in Bihar and Uttar Pradesh where it has become a commercial crop.

Botany

Litchi belongs to the family Sapindanceae. Litchi trees are medium to large, much branched, round topped, evergreen, reaching up to 11 metres or more in height. The leaves are compound consisting of 4-7 leaflets each, about 7-10 cm in length, glossy dark green above and grayish green on the undersuface. The inflorescence is a compound raceme developing both from terminal and axillary buds. Flowers are unisexual, bisexual or intermediate. The flowers of different sexes on the panicles do not open simultaneously. They are found to open in different flushes.

The mature litchi fruits which are one seeded nuts, usually develop in bunches and vary in shape and size according to variety. The fruits are about 2.5 to 3.5 cm in diameter and usually oval in shape. The pericarp is papillate like strawberry and turns pinkish red when the fruit is ripe. Aril is the edible portion which separates easily from the pericap. It is fleshy, succulent, translucent, pearly whtre and soft in texture.

Uses and Nutritive Value

In addition to being a fruit for fresh consumption highly flavoured squash can be prepared. .In China, litchi is used to make pickles, preserves, wine and

dried litchi (litchi nut). Recently, canned litchi has entered the international trade.

The food value of litchi lies in its sugar content which varies due to varieties and climate. The sugar in different varieties ranges from 6.74 to 13.86 per cent. Besides sugar, litchi contains protein 0.7 per cent, fat 0.3 per cent, minerals 0.7 per cent and vitamin-C (64 mg/100 g pulp).

Area and Production

At present the area under litchi constitutes only about 0.75 per cent of the total area under fruits in India. The bulk of the area consisting of 8,380 ha lies in North Bihar (Muzaffarpur Dist rict), 1640 ha in West Bengal (Murshidabad, Nadia, Hooghly and 24-Parganas Districts), 620 ha in U.P., 210 ha in Punjab, 200 ha each in Assam and Tripura and 160 ha in Orissa.

Climate

Litchi growns well in moist subtropical climate. Frost in winter and dry heat in summer are the limiting factors for growing litchi. The temperature should not go beyond 41°C in summer and below freezing in winter. High rainfall is not aboslutely essential if irrigation facility is available. Prolonged rain at the time of flowering is not desirable. Alternate spells of rain and dry heat in summer cause fruit splitting and drop. Litchi usually likes low elevatrions and can be grown up to an altitude of 800 metres with varying degree of success. Young trees need protection aganist frost and hot desiccating winds for several years till they are finally established.

Soil

Litchi does best in deep well drained loam rich in organic matter. The soil should not have a hard pan within 2.5 metres from the surface. In Bihar, the lime content of best litchi regions is about 30 per cent which suggests that in regions where lime is deficient it would be useful to incorporate lime in the soil. However, it connot be grown in alkaline soil, acid soil is preferred. The water table should be at least 1.25 cm deep. It cannot stand water stagnation for a long time.

Varieties

In China threre are about 49 varieties of which 15 are grown commercially. In India the same varieties are known by different names in different places. The important varieties in different locations are as follows :

a. Bihar — *China, Deshi, Dehra, Rose, Purbi, Bedana, Melean, Muzaffarpur.*

b. Western U.P. — *Seedless Early, Seedless Late, Early Large Red, Calcutta, Rose Scented, Khatti* and *Gulabi.*

c. Punjab — *Saharanpur, Dehradun, Calcutta, Muzaffarpur, Seedless Late* and *Rose Scentred.*

d. West Bengal — *Bombai, Elaichi Early, Elaichi Lagte* and *China.*

A brief description of major varieties is given below:

(i) Muzaffarpur: An important variety grown in Bihar and adjacent states. Bearing is profuse and fruits are deep orange to pink in colour and less prone to splitting. Matures in first week of May in Eastern India while it ripens in the middle of June in North India and yields about 80-100 kg fruits per tree.

(ii) Saharanpur: Early and a heavy bearer. Fruits are large, heart shaped

and deep orange to pink in colour. Fruits ripen in first week of June.

(iii) Dehradoon: Medium to high yielding bearing fruits after 5th year of planting. Trees are of medium vigour attaining a height of 5 m and spread of 7 m when fully grown. Fruits are heart shaped to conical, bright rose pink in colour, average weight 18 g, ripen in second week of June. Pulp is grayish white, moderately juicy and sweet. Fruit is susceptible to sunburn and cracking.

(iv) Calucutta: Successful in hot and dry area. Heavy bearing (100 kg/tree) and ripens in last week of June. Fruits are oblong, deep carmine red, mean weight 22 g, pulp is dull creamy white, juicy and very sweet. Fruit less susceptible to sunborn and cracking.

(v) Rose Scented: One of the important varieties in India. Fruit has a distinct rose aroma. Medium yielding variety (80-90 kg/tree) and ripens from 2nd and 3rd week of June. Fruits are mostly globosely heart shaped, deep rose-pink 15 g weight, pulp grayish white and very sweet.

(vi) Seedless Late: Seeds are shrivelled and hence proportion of flesh is more. Trees are vigorous. In a lean year yield upto 40 kg fruits per ktree and in a heavy year 80-100 kg. Fruits ripen in third week of June. Average fruit weight is 29 g. Fruits are moderately susceptible to cracking.

(vii) China: Best variety grown in West Bengal. Trees are semi-dwarf, yield from 60-70 kg per tree, and fruit ripens from 2nd to 3rd week of May. fruits are mostly globose. Pulp is creamy white, very sweet, soft juicy and of pleasant flavour.

Propagation

Air layering (*Gootee*) is the most widely adopted method for propagation of litchi. The best season is the beginning of monsoon i.e. June-July and it can be extended up to August. A terminal branch of 45-50 cm in length is selected for air-layering. A ring or band of bark about 2.5 cm in length is removed from the branch where it is about 1.25 cm in thickness. The cammbium layer is completely rubbed off from the exposed wood. A rooting media consiting of two parts of soil, one part sand and one part leaf mould or cowdung manure or sphagnum moss properly soaked in water is used in the form of a ball. The rooting medium is placed on the ringed portion covering about 2 cm from the upper end of the ring. A piece of polythene film of convenient size is wrapped around the medium and tied properly at both neds. Within 40-60 days roots develop from the upper end of the ring. The rooted shoot may be removed later by giving a sharp cut about 5 cm below the lower end of the ring, preferably in 2-3 stages. There are reports that 5,000 ppm IBA in lanolin state applied at the upper end of the ring helps in rooting.

The other methods are budding (chip and shield), grafting (splice) and inarching. Splice grafting is extensively used in South Africa.

Planting

As hot desiceating winds in summer and cold winds in winter adversely affect litchi plantation, a suitable wind break should be planted along the orchard boundary and it should be at right angles to the direction of prevailing winds. A row of tall growing tree such as seedling mango, *jamun*, eucalyptus or bamboo alternating with low headed trees like

neem are planted 2-3 years before planting litchi in the orchard.

Planting distance: Litchi plants are usually planted 10 metres apart both ways. The distance may be reduced to 8 metres, when the climate is comparatively dry and the soil is not fertile.

Planting season and planting: Planting is to be done when the weather is neither too wet nor too dry. The best planting time is from August to September. Planting in spring and early summer may also be done if irrigation is available.

For planting, pits of 1x1x1 m dimension should be dug at desired spacing. These are then allowed to remain open for a few days and then filled with top-soil mixed with manure and fertilisers at the rate of 20 kg farmyard manure, 2 kg bonemeal and 300 g of muriate of potach.

Training and Pruning

To give proper shape, a certain amount of initial pruning is necessay. Once the desired shape is achieved, no pruning is required except removal of dead or diseased branches and damaged shoots or crossed limbs. As litchi flowers are borne mostly on current year's growth, snipping of old branches to promote new growth is desirable.

Intercropping

As litchi is slow growing and takes least six years to come to bearing, vacant spaces in between the trees can be utilised for intercropping in early years. During summer and kharif season, vegetables like pumpkin, cucumber, ridge gourd, bitter gourd and leguminous crops may be grown. During winter, crops like peas, beans and gram can be grown. Besides vegetables, quick growing fruit crops like papaya, pineapple and banana may also be interplanted.

Manuring and Fertilisation

Litchi needs a high amount of organic matter. The recommended schedule is as under:

Application of FYM, superphosphate (SSP) and muriate of potash (MOP) should be done in autumn. Nitrogenous fertilizers should be applied in two equal doses, one in mid-February and the other after harvest.

If zinc deficiency is noted (general bronizing of leavers), as spray of 4 kg of zinc sulphate and 2 kg of hydrated lime in 500 litres of water may be applied in spring.

Age of the plant in year	*Per plant per year in kg*			
	FYM	*CAN*	*SSP*	*MOP*
1-3	10-20	0.3-1.0	0.2-0.06	0.05-0.15
4-6	25-40	1.0-2.0	0.75-125	0.20-0.30-
7-10	40-50	2.0-3.0	1.50-200	0.30--50
10 and above	60	3.5	2.25	0.60

Irrigation

Adequate soil moisture is essential. Where annual rainfall is more than 125 cm and is well distributed, litchi can be grown without irrigation. If the litchi orchard is not frequently irrigated during spring and summer months in the plains of India, there are chances of severe fruit drop. Depending on availability of water, the orchard may be irrigated at fortnightly

intervals during April and frequency of irrigation may be increased further in May till the fruit is harvested.

Flowering and Fruiting

Litchi trees propagated by air layering come to flowering at the age of 3-5 years with proper care. Flowering starts from late January or early February and fruits ripen in May and June in South India, flowering starts in December and fruits ripen in April-May. Litchi varieties show variation in their flowering and bearing habits and may accordingly be classified as regular, irregular and shy bearing.

Insect Pests and Diseases and Their Control

Insect Pests

Mites: The maximum damage is done by the *Eriophyes sp.* Both adults and nymphs infest the leaves. They cause a browny velvety growth. Pits are formed which develop into galls and finally leaves curl up. Mites suck sap from the leaves causing them to dry up. The attack starts in March and maximum activity is in July. Spraying of Kelthane (0.12 per cent) during the new flush period is highly effective. Alternatively, Dimethoate (0.05 per cent) can also be used.

Caterpillar: In certain regions, a small caterpillar is found to eat the stalk end of the fruit and seed without affecting the pulp. It produces a brown dust like substance and causes considerable damage to ripe fruits thus reducing the market value of the fruits. Spraying with Dimecron (0.6 ml/1), Rogor (3 ml/1) or Thioden (3 ml/1) about 15 days before the fruits mature reduces the infestation.

The bark eating caterpillar also causes damage in litchi by boring into the bark and underlying tissues in the branches. Plugging the holes with fumigants such as Carbon bisulphide, petrol or Formalin and then plastering with mud checks the caterpillars effectively.

Diseases

Litchi is free from any major fungal disease.

Harvesting and Post Harvest Handling

The maturity of the fruit is determined by the flatness of tubercles and comparative smoothness of the epicarp. Besides, the fruit colour changes from greenish to pinkish on maturity. The fruits are harvested in bunches along with a portion of the branch and few leaves. This helps in improving the keeping quality of the fruit. As all fruits do not ripen at the same time, the fruit clusters are spot picked several times. If individual fruit is harvested, the skin at the stem end is ruptured and fruit rots quickly.

After the tree comes to bearing the yield increases till they are 20 to 30 years old. In India a full grown tree on an average bears about 80 to 150 kg of fruits per year.

The fruit does not keep for more than a few days at room temperature. It loses its bright colour and turns brown within 2-3 days after harvest. At 2.2° to 3.3° C and relative humidity of 80-85 per cent, fruits can be stored for one month.

Another method of preserving litchi fruit is drying either in the sun or in an

oven. Sun dried litchi is considered better than artificially oven dried fruit. As the dried flesh and the seed rattle inside the hard shell, the product is called the 'litchi nut'.

The fruit also can be frozen with minumum handling, the natural covering of the fruit is a good packing material by itself and the whole frozen fruit makes an attractive produce. It can also be peeled and frozen in syrup as is done with other fruits. Recently, canning of litchi in large quantities has also been taken up in India.

The fruits for the local market should be collected at the full ripe stage as indicated by the attractive skin colour, while for distant markets the fruits should be harvested when they have just started to turn reddish. After harvest the fruits should be kept in cool, dry and well ventilated rooms because the litchi fruits ripen under high atmospheric temperature.

The fruits are graded and packed in shallow baskets or crates lined with litchi leaves or soft dry grass or banana leaves. Fruits should be packed loose. During transit, care should be taken to avoid crushing of fruit and damage of the skin. Litchi being highly perishable, marketing should be done as early as possible.

Special Problems

Physiological Disorders

Fruit cracking is a serious problem in almost all litchi growing areas of India, particularly under dry bconditons. It is thought to be due to high temperature and relatively low humidity and these factors in combaination with rapid flesh growth and relatively less eleasticity of fruit skin cause cracking. This can be overcome by providing adequate irrigation during development of fruits.

QUESTIONS

1. Discuss the climatic requiremens and nutritive value of litchi.
2. Deserebe the following:
   (a) Flowering and fruiting.
   (b) Fruit cracking.
   (c) Litchi products.
   (d) Intercropping in litchi.
3. Enumerate a few important varieties of litchi and give their characteristics.
4. How is litchi propagated on a commercial scale? Discuss its merits and demerits.

CHAPTER 14

Ber

Introduction

Ber (*Zizyphus mauritiana* Lamk) or Indian jujube is one of the most drought hardy fruits, with potential for good production even under marginal conditions of soil and climate. Thus it is becoming popular under dryland conditions.

Origin and Distribution

Ber is indigenous to an area stretching from India to China and Malaysia. occupies nearly 12,000 ha in India mainly in Uttar Pradesh, Rajasthan, Punjab, Haryana, Gujarat, Maharashtra and Andhra Pradesh. It is also cultivated in Afghanistan, China, Iran, Syria, Myanmar, Australia, France, The United States of America and erstwhile USSR.

Ber fruits are eaten fresh, canned, dried and converted into several products such as ber butter, ber squash or juice. *Ber* fruits are a good source of carbohydrates and vitamins B and C. Even the *ber* leaves provide a nutitious fodder for animals.

Botany

Ber belongs to the family Rhamnaceae. The *ber* or Indian jujube has vine-like growth habit unlike the Chinese jujube (*Z. jujuba* Mill).

The Indian jujube has drooping branches with its leaves rusty tomentose on lower surface and green on upper surface. The Chinese *ber* has dark-red or brown fruits and is also known as Chinese date or Chinese fig. The genus *Zizyphus* contains about 135 species out of which 18-20 are native to India. The other species are *Z. nummularia*, *Z.xylopyrus*, *Z.spinachristi*, *Z.vulgaris*, *Z.oenoplia* and *Z.rugosa*.

Climate

Ber can be grown under different agroclimatic conditions prevailing throughout the country. Dry and hot climate gives better fruits quality and production. Trees undergo dormancy in May-June, and therefore can tolerate adverse hot and dry conditions. It can be grown up to an elevation of 1,000 jmetres. Low temperatures below freezing point are injurious to the fruits as well as shoots of the Indian jujube. But the Chinese jujube can tolerate extremely high and low temperatures. Since climatic conditions in South India are

moderate with no extremes in temperature, there is no check in its growth and thus two crops in a year may be harvested.

Almost any type of soil is suitable for *ber*. It can withstand alkalinity and waterlogged conditions and can be grown on lands which are otherwise unfit for other fruits or crops. It can tolerate a salinity upto 21 mmhos/cm.

Varieties

Nearly 125 varieties of *ber* are available in India but only a few are commercially important. The varieties have been classified into early, mid season and late maturing groups, particularly in North India. Their maturity time tin South India, however, varies.

Early Varieties

Gola: Gola is one of the best varieties grown extensively. Fruits are dround, golden yellow in colour with an average weight of 25 g. The pulp is soft, white and sweet with TSS 16-20° Brix. *Gola* variety is rich in vitamin-C. Each tree can give a yield of 125 kg fruits.

Safeda Selected: Fruits are round, golden yellow with a brown tinge. Fruits contain 90% pulp which is soft, juicy and sweet with TSS of 20° Brix. Yield per tree varies from 85 to 125 kg.

Seb: Fruit is apple shaped, greenish yellow in colour and weighs 15.5-20.5 g. The fruits contain 92% pulp, 20° Brix TSS and 0.32 per cent acidity. Yield per tree is 90-105 kg.

Mid-season Varieties

Kaithali: Kaithali is a popular variety of Haryana and Punjab. Fruit weight varies from 17 to 22g. Fruit colour is brownish yellow and rind is thin but hard with TSS 17.4 to 18.5° Brix. Yields 120-150 kg per tree.

Sanaur 5: Sanaur is an important variety of Punjab. The fruits are roundish with a pointed end; fruit colour is greenish yellow, weighs 15 to 18 g. Pulp soft, creamy white with TSS of 20.5° Brix. Yield 100 kg per tree.

Banarasi Karaka: Banarasi Karaka is a popular variety of Uttar Pradesh. It has also performed well in South India. Fruits are oval, tapering, light yellow and weigh 17 to 20 g.

Late Varieties

Umran: Umran is known for its high yield. It has a potential of giving up to 250 kg fruits per tree. The fruits are oblong and large in size weighing 32.5 to 60 grams. Fruits are yellow coloured with a brown tinge. Pulp is hard, white and sweet (19.5% TSS). Keeping quality is good. It is an important variety of Punjab and Haryana.

Other Varieties

U.P.	*Narma, Pewandi, Murla, Jogia, Aliganj, Ponda.*
Bihar	*Nagpuri, Banarasi, Thornless.*
Gujarat	*Meharun, Ajmeri (Katha)*
West Bengal	*Banarsi Prolific, Narikeli,*
Maharashtra	*Meharun, Katha*
Rajasthan	*Tikadi, Katha, Maharwali*

Propagation

By Seeds

Plants raised through seeds bear fruits of poor quality. However rootstocks are

raised from seeds. Seeds should be soaked in 17-18 per cent brine and floating seeds should be discarded. The seedlings raised by sowing seeds in March-April will be ready for budding in June-July.

By Vegetative Propagation

Ring or shield budding are successful. But shield budding is common. Ninety days old seedlings of wild *Z. mauritiana* are used as rootstoocks. The budding can be done either in plastic tubes in which seedlings are raised or on *in situ* raised seedlings in the field. Management of individual budded plant in the field is difficult. Also plastic tube budded plants can be transported to other places. The seedlings budded in July in the tubes would be ready for transplanting by August.

Budding can be practised on seedlings raised in the nursery. But the survival rate of these plants is low due to root injury while uprooting. Moreover transport of plants with ball of earth is difficult. Such plants can, however, be transplanted bare rooted during winter. But, the survival of these plants in rain fed areas would br poor.

Ring budding can be done during June when the stock plants have attained pencil thickness. It is, however, difficult to get sufficient number of scion buds of equal thickness to perform the budding at this time.

In Chinese jujube inarch grafting is done on rootstock plants raised by sowing wild Chinese *ber.*

Planting

Pits of 1 m^3 dug at a spacing of 8 m x 8 m before the onset of the monsoon are filled with soil mixed with 50 kg farmyard manure, 2 kg super phosphate and 30 g 5 per cent Aldrin or 50 g 5 per cent BHC dust. The budded plants are transplanted during Aug-Sep. With the spacing of 8 m x 8 m, 152 budded plants are required to cover one hectare area. It is better to select young plants. Old plants with coiled roots perform poorly, particulary, under dry land conditions.

Intercultre

Orchard should be kept free of weeds by shallow tillage. Plants of wild *Zizyphus sp.* should be destroyed lest they serve as alternate hosts to powdery mildew and fruit-flies. The suckers that appear from the rootstock should be removed.

Training and Pruning

It should be ensured at planting time that the plants have straight, uncoiled roots. After planting, building of proper framework takes about two years in south and west India and three years in north India. From the ground level, one upright growing vigorous shoot is encouraged by beheading the plant after establishment from above the bud union. Three to four secondary branches are allowed in different direction starting at a height of 30 cm. Only one branch is allowed from one node. After one season's growth, these secndary branches are beheaded from close to the trunk to encourage vigorous secondaries. From these secondaries, upright growing tertiary branches are similarly encouraged during the following season.

Pruning of *ber* trees should be done every year for production of goodd quality fruits. In north India, pruning is done during middle of May. In Maharashtra it should be done before end of April and

in south India during April. The past season's primary shoot is pruned to about 25 buds and all its secondaries are completely removed. It is better to prune about half the prmiary shoots to about 25 buds and the remaining half to 2-3 buds so that every year there is renewal of growth along with good fruiting.

Manruing and Fertilisation

The doses of nutients will be different for irrigated and rain fed orchards. Under irrigated conditions, following doses are recommended:

Age in	*Nutrients g/plant/year*		
year	*N*	P_2O_5	K_2O
1-2	75	50	50
3-5	150	100	100
Above 5	200	200	200

In addition, 100 kg farmyard manure should be aplied to each tree.

Under rain fed conditions, the doses should be reduced to 30 kg farmyard manure, 100 g N, 50 g P_2O_5 and 50 g K_2O per tree, and the application should be done during monsoon.

Irrigation

Young plants should be irrigated regularly at 7-10 days interval. Grown up trees do not need much water as they would have developed a deep root system. Irrigation during flowering and fruit set enhances the yield. Various techniques to harvest run off water such as cres cent bunding and provision of micro catchment will be useful. Plants budded *in situ* can withstand drought more efficiently.

Intercropping

Annual crops like *mung, guar,* gram, *berseem* and fruit crops such as papaya and *phala* can be grown for 2-3 years. Some farmers grow crops like *bajra* and wheat which is not advisable.

Flowering and Fruiting

Flower buds appear in the leaf axils on the main as well as lateral shoots of both current seasouns as well as mature growth. The inflorescence is an axillary cyme. Each inflorescence will have 12-14 flowers. In North India, the flowering continues for three months from first week of September to the middle of Novermber. The fruit set occurs in October. In south India flowering may continue throughout the year but is mainly during July to September and the fruits set occurs in August. *Ber* varieties are self unfruitful. Some varieties of *ber* are also cross-incompatible and show pollen sterility.

Application of GA and 2,4 5-T improves fruits set. Application of 2,4-Dat at 10 and 15 ppm improve fruit set in *Dandan* and *Umran* varieties. In *Banarasi Karaka*, 50 ppm dspray of GA increased fruit set from 9.6 per cent to 27.80 per cent. The beneficial effects of FA and auxins may be due to their effect on pollen germination and pollen growth.

A heavy fruit drop follows immediately after fruit set either due to lack of pololination or due to disintegration of ovules. Abortion of embryo contributes to 29 per cent fruit drop. Fruit drop occurs mainly in October, November and December. Exogenous application of growth regulators have not been very effective in preventing fruit drop.

Application of 10 ppm NAA has been found to increase the fruit size and TSS in *Banarasi Karaka* variety. Fruit development takes about four months in early varieties and about six months in late varieties.

Insect Pests and Diseases and Their Control

Insect Pests

Fruit-fly (*Carpomyia vesuviana*)

Fruit-fly can cause as high as 80 per cent damage to the fruits. Females lay eggs inside the fruit by oviposition. The maggots feed on the pulp and make galleries making infected fruits unfit for consumption.

Male fruit flies can be trapped in traps containing 1 ml Methyle eugenol, 2 ml Malathion and 100 g jaggery in one litre of water.

Hairy caterpillar (*Euproctis fraterna*)

The caterpillar can be controlled by spraying Sevin at 3 g per litre of water.

Lac Insect

The attacked shoots dry up. The affected branches should be cut back and Rogor at 1 ml per litre of water should be sprayed.

Diseases

Powdery Mildew (*Oidium sp.*)

The developing young leaves show white powdery mass which ultimately causes defoliation. *Sanaur-5* and *Safeda Selected* varieties are comparatively tolerant to this disease.

It can be controlled by spraying 0.05-0.1 per cent Karathane or wettable sulphur.

It is important to make a prophylactic spray just before flowering, particularly in places where the disease occurrence is established.

Fruit Rot

Fruit rot caused by *Phama sp., Colletrotichum sp.* And *Alternaria sp.* can be controlled by spraying 0.2 per cent Dithane Z-78.

Leaf Spot

Alternaria sp. and *Cercopora sp.* can be controlled by 0.2 per cent Dithane Z-78 spray.

Harvesting and Post Harvest Handling

In northern India, different varieties of *ber* are harrested between the middle of February to middle of April. In Rajasthan, the harvest season is between January-March; in Gujarat between December and March; and in south India, harvesting begins by Novermber.

Harvesting of fruits is usually done in the morning by hand picking. A ladder is used to reach the upper branches of the tree. the fruits are packed in gunny bags, baskets or in cardboard cartons depending on quality and grades. The poorest quality is packed in gunny bags. The stroage life of fruits varies with variety. Fruits of *Umran* have good storage life whereas those of *Gola* and *Seb* have poor storage life. Storage life can be improved by harvesting the fruits at a greenish yellow stage, proper cleaning and packing.

About 80 to 200 kg fruits per tree from 10-20 years old trees can be harvested. In dry areas, under rain fed conditions the yield per tree is 50-80 kg/tree.

QUESTIONS

1. What makes the *ber* highly suited as a crop for dry land orcharding?
2. Discuss the commercial vegetative methods followed to propagate *ber* along with their advantages and disadvantages.
3. Explain the problem of fruiting in *ber* and what methods would you suggest for obtaining higher yields.
4. Write short notes on:
   i. *Umran*
   ii. Fruit-fly
   iii. Chinese date
5. Is regular pruning in *ber* necessary? Describe the method of pruning in *ber*.

CHAPTER 15

Aonla

Introduction

Aonla (*Emblica officinalis* Gaertn.) is also known as embolic, myrobalan, *amla* or *nelli*. The fruit is highly nutritive. It is a rich source of vitamin C. (600 mg/100 g), vitamin B, nicotinic acid and iron. Its fruits are used in different Indian medicines since antiquity. Its *murabba* is used as very good health tonic. It is also used in the preparation of various types of hair oils. Even the dried products of *aonla* such as pickles, candy, dried chips and toffee contain appreciable amonts of vitamin C. This retention of vitamin C is due to the presence of polyphenols and leucoanthocyanins.

Origin and Distribution

Aonla (Indian gooseberry) is native to tropical and souteastern Asia, particularly central and southern India. It grows well throughout tropical India and is seen growing commonly in mixed deciduous forests of India as well as on the hill slopes. It is found growing in different states even up to an elevation of 1,500 m in south India. It is more popular in the districts of Azamgarh. Faizabad, Varandasi and Bareilly of Uttar Pradesh.

Botany

Aonla belongs to the family Euphorbiaceae. There are about 500 species under the genus *Phyllanthus*. The small gooseberry (star gooseberry) is *Phyllanthus acidus*. Aonla is a medium sized tree but can grow upto 18 metres in favourable situations. Although it sheds its leaves, it is seldom deciduous. The leaves are small. The fruits are stalkless and smooth. The surface is smooth, shiny and the size varies from that of a smll marble to a large onion. The stone inside is hexagonal containing six small seeds. The fruits have a sour acrid taste.

Climate and Soil

Well drained dertile loamy soils are the best. However, it can be grown on light as well as heavy soils. It can be grown on moderately alkaline soils also.

Aonla is essentially a subtropical plant. But it can be grown even in the tropics. Young plants have to be protected from hot winds during May-June and from frost during winter at least up to 3-4 years. The mature plants can tolerate freezing temperature and temperatures

as high as 46°C . Warm season is conducive for the initiation of flower buds. It can be grown up to 1,500 metres above mean sea level.

Varieties

The following varieties are popular in *Aonla:*

Banarasi: Banarasi is an early variety. Fruits are large, flattened, conical, yellowish with lobed base, smooth skin and with six segments raised in three parts. The flesh is soiled, fibreless, soft and transpartent. It is a shy bearing variety and has a very low number of female flowers per branchlet. The fruits are suitable for *murabba* preparation.

Hathi Jhool or Francis: Hathi Jhool is a mid season variety. The fruits are large, greenish in colour, flattend oval with thin skin and six distinct and solid stripses,. The flesh is fibreless and soft. Fruits are suitable for *murabba* preparation. It is very prolific bearing and vigorous, but fruits are susceptible to necrosis.

Chakaiya: Chakaiya is a late variety. The fruits are small, greenish, flattened with thin and smooth skin and six distinct strips. The flesh is fibrous, hard, solid and is good for pickle. It is a prolific bearer.

Krishna: Krishna is a mid season cultivar. The fruits are yellowish, flattened, conical with papillate basin, very smooth skin and angular and raised stripes. The flesh is fibreless, soft and transparent. It is a prolific bearer.

Kanchan: Kanchan is a late veriety. The fruit is medium in size, oblong, yellowish, flattened with six distinct and solid stripes. The segments are flat and the flesh is fibrous and hard. It is a prolific bearer.

Narendra Aonla-7: Narendra Aonla is a chance seedling of *Francis*. The fruits are large, free from necrosis and are fibreless. It is precocious and prolific bearer. It comes to bearing within 4-5 years after planting.

Some of the other *aonla* varieties being grown are:

Gujarat	*Gujarat Aonla-1, Anand-1, Anand-3.*
U.P.	*Red Tinged, Green Tinged, thite Streaked*

Propagation

By Seeds

Seed propagated plants are not true to type and produce small sized fruits of inferior quality. Seedlings can, however, be used as rootstocks. Seeds attain full maturity by February when they should be extracted and sown. Higher percentage of germination (92.5 per cent) can be obtained by treating the stones with 500 ppm GA for 24 hours.

By Vegetative Propagation

(a) Budding

Shield budding is the commercial method of proagation in north India. One year old aonla seedlings with a stem girth of 1 cm can be shield budded in early June with plumpy buds from new growth. Shield budding gives success upto 70-80 per cent. Forkert method of budding can also be employed. Bud wood should be taken from fruitful branch having a good number of female flowers.

(b) Grafting

In situ softwood grafting can give up to 70 per cent success.

(c) Top working

Old trees of inferior type can be rejuvenated through top working. For this, the trees should be headed back at a height of 1.2 m from the ground level during. March and the new emerging shoots can be budded in early June by T-budding.

Planting

Prior to planting, the field should be ploughed deep and levelled. Pits of 1 m^3 size should be dug with a spacing of 9-11 m during May-June. The pits are filled with surface soil and farmyard manure at 10-15 kg/pt. Plants can be raised *in situ* for budding, particularly in dry regions.

The plants should be protected from extremes of weather during the initial two years.

Training and Pruning

The *aonla* plants have to be trained on modified leader system. Four branches are developed on the trunk starting at 0.75 m height. These should be well spaced in different directions.

Pruning may be done after the fruit harvest to remove the dead and diseased branches.

Irrigation

Young plants need watering. The older plants are quite hardy and can resist drought. Watering of plants during flowering and fruit set reduces fruits drop. It is usually done at 20 days interval during October-December.

Manuring and Fertilisation

The following nutients should be applied in two split deses once during September-October and then during April-May:

Age in year	*Nutrients g/plant/year*		
	N	P_2O_5	K_2O
1-2	75	50	50
3-5	150	100	100
Above 5	300	200	200

In addition, 15-20 kg FYM to each young plant and 30-40 kg FYM to each mature tree should be applied during September-October.

Intercropping

During rainy season, leguminous crops like *mung*, etc, can be grown during the initial eight years.

Flowering and Fruiting

The flowers start opening from last week of March and the blooming period lasts for three weeks. The budded plants usually come to bearing six to eight years after planting.

Aonla produces a large number of male flowers. The ratio of male to female flowers differs widely with varieties. In *Banarasi* variety, lack of pollination and low sex ratio causes poor fruit set.

First fruit drop which occurs within three weeks of flowering is due to the degradation of egg apparatus and lack of pollination. The second drop occurs from June-September due to lack of pollination and fertilisation. The third drop consists of fruits of various stages from the third

week of August until October, mostly due to fruit physiological factors. After set, the embryo sac lies in a dormant condition and the ovary does not exhibit any symptoms of external growth until middle of August. Therefore, fruit size increases and reaches the maximum by November.

Insect Pests and Diseases and Their Control

Insect pests

Bark Eating Caterpillar (*Indarbela spp.*)

The caterpillars tunnel the main trunk and branches. The pest can be controlled by injecting petrol or kerosene oil into the tunels and plugging the holes with cotton or wet clay.

Shoot Gall Maker (*Betonsa stylophora*)

Young caterpillars bore into shoots. The affected region develops into gall. Pruning the affected parts and spraying with 3 per cent Parathion can control this insect.

Diseases

Anola rust (*Ravenellia emblicae*)

Brown pustules are formed on leaves and fruits. These pustules become dark brown. Spraying with Dithane Z-80.2 per cent controls this disease.

Blue Mould (*Penicillium islandicum*)

Brown patches with water soaked lesions appear on fruits. Later they are covered with bluish-green pustules. Treatement of fruits with weak NaC1 solution can effectively control this disease.

Internal Fruit Neerosis

Internal fruit necror is per cert is a physiological disorder believed to be caused due to boron deficieny. Three sprays of borax 0.6 per cent once in 15 days commencing from early September has been recommended to overcome this disorder.

Harvesting and Post Harvest Handling

Aonla plants come to bearing six to eight years after planting. December-February is the best time for harvesting fruits, when vitamin-C content in the fruit is at its highest.

The fruits are generally harvested by shaking the trees but to avoid spoilage, fruits should be hand picked. the fruits are packed in bamboo baskets with a paper lining. Cardboard cartons are also used. The fruits have fairly good keeping quality.

A full grown grafted *aonla* tree yields from 187 to 290 kg fruits per year.

QUESTIONS

1. State the important uses of *aonla*.
2. Name some of the new varieties developed and describe their salient features.
3. Discuss the problem of fruit drop in *aonla* and explain the causes for fruit drop at each stage.
4. Enumerate the important pests and diseases of *aonla* and give their control measures.

CHAPTER 16

Pomegranate

Introduction

The pomegranate (*Punica granatum* L.) is one of the favourite table fruits in tropical and subtropical contries. The fruit is liked for its cool, refreshing juice and its processed products, like bottled juice, syrup and jelly. Pomegranate is also valued for its medicinal properties. The bark and rind of the fruit are commonly used for treatment of dysentery and diarrhoea. The juice is believed to be useful for patients suffereing from leprosy. The rind is also used as dyeing material for cloth.

Pomegranate belongs to the family punicaceae. It is a small shrub and if trained properly assumes the stature of a small tree.

Origin and Distribution

Pomegranate is a native of Iran and is cultivated extensively in Spain, Morocco and other countries around the Mediterranean, Egypt, Afghanistan, Baluchistan and Saudi Arabia. It is also grown in Myannar, China, Japan and California (USA).

In India, pomegranate is grown on a small scale in almost all the states. However, in recent years it has assumed commercial significance in the states of Maharashtra, Karnataka, Gujarat and Rajasthan.

Climate

Pomegranate can adapt itself to a wide range of climatic conditions. It is deciduous in areas with low winter temperature, and it evergreen or partially deciduous in tropical and subtropical conditions. Hot and dry summer and cool winter conditions are ideal for its cultivation. The quality of fruits is adversely affected in a humid climate. Pomeegranate is a hardy plant capable of withstanding drought, but it bears well under irrigated conditions.

Soils

Pomegranate is not very exacting in its soils requirement and can be grown on diverse types of soils. Deep loamy alluvial soils are ideal. Pomegranate is tolerant to limy or slightly alkaline soil conditions.

Varieties

There are several varieties grown in India,

and are different in shaape and size of fruit, colour and thickness of rind, colour of aril and softness of seeds. The following varieties are commercially important.

(i) Ganesh (GBG-1) : Ganesh is a selecion made at Ganeshkhind Fruit Experiment Station, Pune. The fruits are medium large to large and arils are pink in colour, with soft seeds and high TSS. This is the most important commercial variety of north Karnataka and Maharashtra.

(ii) Bassein Seedless: The fruits are medium sized, with a greenish yellow skin colour. Arils are pinkish white with soft seeds. This variety is also popular in Karnataka.

(iii) Jyothi (GKVK-1): Jyothi is a selction made from Bassein Seedless at UAS, Bangalore. The fruits are medium to large in size and have an attractive colour and high pulp Wantent. Arils are deep pink in colour with soft seeds, high TSS (16. per cent).

Propagation

Pomegranate can be propagated either by seeds, cuttings or by air layering. As vegetative propagation eliminates variation in tree growth and productivity, it is propagatd commercially only by cuttings or air layers.

(i) Stem Cuttings

Stem cuttings is the most common method of propagaion. Hardwood cuttings are taken from fully mature strots of about one year age. Wood younger than 6 months or older than two years is unsuitable. The cuttings are usualy made from suckers which spring from the base of the main stem and have borne fruits. Cuttings may be 6 to 12 mm in diameter and 25-30 cm long.

While some varieties root profusely and early, other varieties like *Ganesh, Jyothi* and *Bassein Seedless*, root to the extent of only 60 per cent. This can be increaed to 75 per cent by treating the cuttings with IBA at 50 ppm (soaking the base for 198 hours). Cuttings may be planted in December-January after pruning. The rooted cutting will be ready for planting in June-July.

(ii) Air layering

Air layering of one year old shoots, after they have borne fruits, is done during December to March. The layers root within 40-50 days and become ready for separation in 80-90 days. These can be kept in pots or plastic bags in the nursery for about two months before planting or disposal.

Planting

The layout of the plantation is done in square or hexagonal system of planting at 5 m x 5 m spacing. For high density plannting, the plants are spaced 2.5×2.0 m (2,000 plants/ha) or 3 × 3m (1110 plants/ha) or 5 × 2 m (1,000 plants/ha) depending on soil fertility and irrigaiton resources.

For planting pits of 50 cm^3 (50 × 50 × 50 cm) are dug and filled with 20 kg farmyard manure mixed with surface soil. Rooted cuttings or layers are planted in the centre of the pits during monsoon months, anytime during June to September. If irrigation is avcailable, planting can also be done during January-February. Newly set plants require irrigation daily for about a week (if the weather is dry) to enable proper establishment and growth.

Training and Pruning

If not trained, pomegranate grows to form a crowded bush giving a number of weak limbs which would not bear much crop. Therefore, it should be trained in either of the following ways.

(i) Single stem

For this, the most vigorous, straght growing shoot is selected. This is cut at a height of 1 metre, so that 4-6 side branches will develop up to a height of 50-60 cm, the first branch being at a height of 35-45 cm from ground level. The other shoots should be regularly removed. the selected branches are also pruned when these attain over 45 cm lenght. The scaffold limbs are again pruned after 6-9 months. Only upright growing shoots are retained.

(ii) Three stem

Since pomegranate has a bushy nature of growth, training it by raising three stems from ground level has given good productivity. For this, after about 6-12 months of growth, the bush is cut at ground level. From the several shoots which emerge, the three most vigorous and well spaced ones are selected and trained. Similarly, as in the case of single stem, except that not more than three side branches are allowed from each stem and these should not criss-cross with the others.

Pomegranate fruts are borne on spurs (short branches) arising on old shoots. Old spurs become unproductive. therefore, while attending to the annual pruning during December-January, old and unproductive shoots with over 4 year old spurs are also removed. Dried and criss-crossing branches are thinned to provide aeration in the crown gegion.

Intercropping

During the first 5-6 years of planting, vegetable crops like onion, cole crops, tomatoes, brinijal, radish, beans, cowpea, and fodder crops like lucerne, etc, can be grown. Certain green manuring crops like sunhemp, can also be grown during the monsson and incorporated into the soil to improve the texture and fertility of the soil.

Manuring and Fertilisation

To obtain economic yields, pomegranate should be manured regularly. The doses are increased as the plant grows in age after planting. The recommended manual schedule is shown in the table given below.

Young plants are manured before the start of the monsoon. To bearing trees, application is done at the time of bahar treatment which varies in different parts of India. Where *mrig bahar* is taken, whole of organic manure, phosphatic and pootassic fertilisers and half of nitrogenous fertilisers are applied dring the monson, when flowering is desired,

Nutrients	*Age* (kg)	*FYM* (g)		
		N	P_2O_5	K_2O
At planting	20	-	-	-
1 year	10	100	50	50
2 year	20	200	100	100
3 year	30	300	150	150
4 year	40	300	200	200
5 year onwards	50	625	250	250

and the remaining half of nitrogen is applied during September. For *ambe bahar* crop, this is done during February and the remaining part of nitrogen is applied during May.

Irrigation

Pomegranate orchards need assured irrigation. Irrigation gives response both in terms of productivity as well as quality of fruits. The interval and time of irrigation depends on the particular *bahar* treatment in a region. Irrigation is witheld at least a month before dthe desired flowring time. During flowering and fruit development period, irrigation is given at an interval of 7 to 10 days. During the monsoon period, irrigaion can be done initially by ring method and then in basins. Drip irrigation has been successfully used in pomegranate, which results in about 40-50 per cent saving of water.

Flowering and Fruiting

In evergreen varieties, flower buds of spring flush are borne on mature wood of the previous season's growth, whereas the flowers which appear during July-August are borne on the current year's growth. The flowers appear in clusters either terminally or in axils of the leaves. Both, self and cross-pollination occurs in pomegranate. However, percentage of fruit set recorded was more by hand and natural pollination than by self pollination.

Although the pomegranate tree may continue to flower and fruit throught the year, there are three main flowering seasons, viz. June-July (*Mrig bahar*) conciding with the monsoon, February-March (*Ambe* or *Ambia bahar*) and September-October (*Hasth bahar*). The fruits from these *bahars* mature during October-December, June-August and February-March, respectively. The fruits mature in 130-180 days after fruits set depending upon season and location.

For commercial production, fruiting only once a year from the most suitable *bahar* in the region is taken. This is done by regulating the flowering (*Bahar treatement*). *Bahar* treatment is normally done when the tree starts bearing a sizeable crop, i.e. about four years after planting.

Mrig bahar is preferred in dry areas where water is scarce, while in high rainfall and humid areas *Ambe bahar* is preferred to avoid spoilage of fruits owing to disease and pest infestation during the monsoon period. Fruits from *mrig bahar* crop develop darker pink aril colour, since the fruit matures during winter *mrig bahar* is preferred by the farmers at large.

To force *mrig bahar* flowering, irrigation is withheld from December to April-May. The basins are dug up and the interspace ploughed up to a depth of about 10 cm. The manures and fertilisers are applied, followed by a light irrigation and then 2-3 irrigation till the rains set in. The trees start growing in June and produce flowers and fruits which ripen during October to December.

To induce *Ambe bahar* flowering, shallow digging is done when the trees shed their leaves by October-November. the manures and fertilisers are applied in December-January followed by one irrigation. Flowering starts within a month and fruts are harvested in June-July.

It is not possible to induce *Hasth bahar*, since watering of trees cannot be withheld during the monsoon.

Cracking of Fruits

The fruits, particularly of *mrig bahar* which ripen during the rains, are susceptible to 'cracking' owing to rapid and wide variations in soil, moisture and atmospheric humidity, causing considerable losses. If rains occur at regular intervals, the fruits would develop normally but when there is a break in the rains, the growth of the fruits is arrested and the elasticity of its rind gets reduced. When it rains again, the fruits rind is not able to expand in proportion to its internal growth, and cracking occurs. It is, therefore, necessary to irrigate the trees regularly whenever there is a break in the rains during the monsson. Covering the fruits with plastic paper or leaf covers also reduces cracking to some extent. Spray of gibberellic acid at fruit set has also been reported to be helpful in reducing fruit creacking.

Plant Protection

Insect Pests and Diseases and Their Control

i. Pomegranate Butterfly (*Virachola isocrates*)

This is the most serious pest. In this case the caterpillar bores into fruit and feeds on the pulp below the rind. Subsequently, infected fruits rot and drop off. It can be controlled effectively by three sprays of any systemic insecticide like Dimecron (1 ml/1) or Rogor (2 ml/1). The first spray would be given when the trees is in full bloom, while the second and third sprays are to be given at weekly intervals thereafter.

(ii) Leaf Spot

Leaf spot is a serious disease causing leaf fall and spots on fruits. They are associated with *Cercospora spp.* and *Gloeosporoides spp.* Spraying three times at fortnightly interval with Dithane M-45 (0.2 per cent) or Dithane Z-78 (0.2 per cent) or Bavistin (0.05 per cent) gives satisfactory control.

(iii) Squirrels and Birds

Squirrels and birds cause serious losses to immature as well as mature fruits. These can be protected by baiting and by enclosing half mature fruits (2-3 months old) with coloured polythene bags. The bags should have vents made by cutting the corners at the bottom.

Physiological Disorder

Fruit cracking is the most serious physiological disorder in pomegranate which limits its cultivation. In young fruits, it could be due to boron deficiency but fully grown frutis crack due to day and night atmospheric mosture deficit. Prolonged drought causes hardening of peel and if this is followed by heavy irrigation or downpour then the pulp grows and the peel cracks. There are some varieties which are tolerant to this disorder like *Bedana Gulesha* and *Khog*. This problem can be managed through following means:

- Maintaining soil moisture and not allowing wide variation in soil moisture depletion.
- Cultivation of tolerant varieties.

- Early harvesting, not allowing fruits to crack.
- Spray of calcium hydroxide on leaves and fruits, after fruit set.

Given proper management this crop has a great future in arid and semi-arid regions of the country.

Harvesting, Yield and Post Harvest Handling

The trees bear fruits in the fouth year when a small crop of 20-25 fruits may be harvested. The fruits are harvested when the skin turns slightly yellow. They give a metallic sound when knuckled and a crackling sound when pressed.

The bearing increases with age of tree. A ten year old tree may bear 100 to 150 fruits on an average weighing 20 to 30 l although in a well managed orchard, it is possible to obtain a yield of 200-250 fruits per tree per year. A nine year old tree of *Jyothi* (GKVK 1) cultivar has recorded a yield of 250 fruits, weighing 50.2 kg per tree.

The average yield of different commercial varieties range from 10,000 to 12,000 kg/ha.

After harvest, the fruits are graded according to their size and packed generally in bamboo baskets. Boxes made of light wood are used for packing premium quality fruits in which individual fruits are put; after wrapping in tissue paper. Fruits can also be cured in shade for a week before packing to improve their keeping quality. They can also be cold stored at 0-4.5°C for a long time.

QUESTIONS

1. Why are pruning and training in pomegranate important? Discuss the different types of training methods followed.
2. What is *bahar* treatment? Explain it in detail, stating their merits and demerits.
3. Describe briefly the fertiliser and water management in pomegranate.
4. What are the important insect pests and diseases of pomegranate? Give their control measares.
5. Write short notes on:
   a *Ganesh*
   b. *Bassein Seedless*
   c. *Jyothi*
   d *Fruit craking*
   e. *Pomegra note Butterfly*

CHAPTER 17

Apple

Introduction

Apple (*Malus pumila Mill* or *Malus sylyestris Mill*) is the most important fruit crop of temperate regions. It is rich in carbodydrates, and minerals like iron and vitamin A.

Origin and Distribution

Apple is native of south-western Asia, western Europe dominates in apple production. Major apple producing countries are:

Europe	—	France, Germany, England, Italy, Belgium, Russia, Poland and Rumania.
N.America	—	U.S.A. and Canada.
S. America	—	Argentina, Chili, Peru.
Asia	—	China, India, Japan, and Korea.
Others	—	Australia, Israel, New Zealand.

In India apple is produced mainly in Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh. Arunachal Pradesh, Nagaland and Sikkim also produce small quantities of apple.

Botany

Apple belongs to family Rosaceae and genus *Malus* which includes 25 species. The cultivated species is *Malus pumila* or *Malus sylvestris*. It is a decidous tree. The tree is round headed growing up to 12 metres or more, with tomentose or densely pubescent young growth. Leaves are oval or elliptic to broad ovate, 5 to 10 cm long, thick and veiny mostly short, pointed, broad at the base, becoming glabrous and more or less glossy above, pubescent below and bluntly serrated. Flowers are white or pink. Fruit is a pome and structurally is the swollen thalamus.

Area and Production

The total world annual production of apple is 20-25 million tonnes. In India area under apple is approximately 1,78,305 hectarea with an annual production of 8,61,404 tonnes. The statewise area and production is given in Table 17.1.

Climate

Apple can normally be grown in areas where winters are cold. The tree has a dormancy and rest period during which it requires adequate chilling or exposure to low temperatures for a certain length

of time to enable the buds to open naturally and satisfactorily in the spring. This is known as chilling requirement. The chillin requirement of 800 to 1,600 hours during winter below 7°C are essential for bud breeak and flowering. Such areas in India are located between 1,500 to 2,700 m above sea level. After a comparatively warm winter, the trees sprout and blossom irregularly and set poor crops, whereas, they blossom spontaneouly and profusely after winters of pronounced low temperatures. the availability of plenty of sunshine and freedom from spring frosts are essential for good crops. The areas with temperatures of 21-24°C during growing season having an annual rainfall of 100-125 cm without droughts spells are suitable for successful cultivation of apple.

Varieties

The apple varieties can be categorised into three groupls:

I. Standard Varieties

The group includes the main commercial varieties of India. These are of three types.

a. Early — *Tydeman's Early Worcester*

b. Midseason — *Royal Delicious, Red Delicious, Rioch-a-red, Vance, Top Red, Lord Lambourne.*

c. Late — *Golden Delicious, Ambred, Yellow Newton Granny Smith, Ambri,*

Table 17.1 : Area and Production of Apple in India (1987-88)

State	*Area (ha)*	*Production (t)*	*Productivity (t/ha)*
Arunachal Pradesh	3,373	4,821	1.43
Himachal Pradesh	55,000	2,49,000	4.71
Jammu and Kashmir	67,422	4,27,063	6.33
Nagaland	60	70	1.00
Sikkim	450	450	1.00
Uttar Pradesh	52,000	1,78,305	3.27
Total	1,78,305	8,61,404	4.83

Soil

Sites with gentle slope are generally more suitable than flat or too steep ones. Loam or clay to sandy loam soils, rich in organic matter, having good drainage and pH of 5.8 to 6.2 are generally recommended for apple cultivation. There should not be hard substrate and waterlogging.

II. Spur Type Varieties

These are the improvements over standard varieties, they bear on spurs and the trees are mostly dwarf — *Red Spkur, Gold Spur, Starkrimson.*

III. Low Chilling

These are the varieties for warmer areas

with lower winter chilling — *Michael, Tropical Beauty.*

The characters of some of the important varieties are given below:

1. Tydeman's Early Worcester: Fruit is round; skin solied red; flesh firm, subacid; matures in mid July.

2. Royal Delicious: Fruit large, conical; skin yellow with red stripes; flesh firm, sweet, juicy and aromatic; bearing fairly regular; vigorous, upright with narrow crotch angles, fruit matures in the second week of August.

3. Red Delicious: Fruit long, conical in shape with protuberances near the calyx; skin yellow with sparse red stripes; flesh firm, sweet and juicy, matures in the third week of August.

4. Rich-a-Red: Fruits conical sweet and juicy skin with red blush, colour earlier than *Red Delicious* matures in the third week of August.

5. Stark Crimson: This varety is spur type, fruit is conical, small; skin with solid red blush; flesh sweet, aromatic, juicy, fruits get darkened with the advancing season, regular and heavy producer, matures in the last week of July.

6. Golden Delicious: Fruits round, conical to oblong, greenish yellow turning to golden yellow on maturity; flesh crisp, juicy and pleasantly flavoured; it is a good pollinizer for Delicious group of varieties.

7. Red Spur: A variety evolved from *Royal Delicious* anmd is spur bearing. Fruit is conical, red skinned, the size is 65 per cent of original standard tree, and matures in the second week of August.

8. Ambri: An indigenous and extensively grown variety in the Kashmir Valley. Fruit medium to large, elliptical, tapering; skin yellowish green, tough, smooth and ¾ th stripped with red colour; flesh white, tender, crisp, juicy and aromatic; good keeping quality; a good cropper and regular bearing; picked at the end of September.

9. Michael: Fruit medium sized, roound with deep cavity; skin yellow with red cheeks; flesh juicy, firm, sub-acid; low chilling and early variety, matures from mid June to end of July.

10. Tropical Beauty: Fruit size medium, skin red, flesh crisp, eating quality good, restricted to warmer climate.

11. Vance: Bud mutant of *Delicious*, fruit conical; skin solid red, colouring at least two weeks earlier to *Sparking Delicious*, Matures in the second week of August.

12. Top Red: Bud mutant of *Shotwell Delicious;* fruits large, conical; skin striped, fruit colours up earlier than *Sparking Delicious*, flesh yellowish, firm, tender, juicy, armatic, subacid; matures in the second week of August.

Propagation

Propagation is done by budding or grafting. Budding is done in the months of May or June and the method adopted is shield budding. When grafting is done for the production of nursery plants, bench grafting or tongue grafting method is used. Certain rootstocks, particularly the locoal types evolved at East Malling, England exert a considerable influence on the scion variety grafted on them. The stock influence may be reflected in tree size, its vigour, cropping and precosity.

Raising of Plants in the Nursery

The apple plants are raised either on seedling rootstocks. The seedlings are raised from either seedling rootstocks or on clonal rootstocks.

Seedling Rootstock

Apples in India are generally raised on seedling rootstocks. The seedlings are raised from either crab apple or from the seed of commercial varieties. The seeds are sown after stratification in February-March in well prepared beds. Seeds before sowing are stratified in moist sand either in the open or in a refrigerator for 2-3 months at 2°-5°C. Generally tongue grafting is done in the succeeding winter after sowing and the plants become fit for sale a year later. T-budding can also be done in May-June on unsuccessful grafts. The trees produced on seedling rootstocks are generally vigorus and tend to be late in bearing.

Clonal Rootstock

The commercial method of propagation of clonal rootstocks is by mound or stool layering. Stoolbed is started by plantng a rooted layer in a small trench 45 cm apart and mother plant is allowed to grow for one season to get it established. Top is then removed to about 2.5 to 3 cm above the ground just before growth begins. When new shoots are 8 to 12.5 cm in height, half of their growth is covered with soil. Soil is then mounded at intervals until it is 15 to 25 cm deep. At the end of the season, roots will be formed at the base of the covered shoots.

Rooted layers are cut off as close as possible to the base and are lined in nursery rows. Trees on clonal rootstocks should be planted on comparatively flat, deep, fertile soils preferably with irrigation facilities.

Promising Clonal Rootstocks

These are as under:

M-9: The tree on this stock grows up to 2-5 m in height (dwarf). Anchorage is poor and requires support. Precosity is excellent and comes into bearing 2 to 3 years after planting. It does not do well under drought conditions, but is resistant to collar rot and has a spreading habit.

M 26: The tree on this stock grows upto 3 to 4 m in height. Trees are precocious and come into bearing in 2 to 3 years. They do well in heavy wet soils. It is susceptible to collar rot.

M-7: The tree on this stock grows upto 4.5 to 5.5 m in height, precocious and anchorage is good, takes 3 to 5 years to come to bearing, well adapted to all kinds of soils, moderately resistant to collar rot, suckers profusely and has a spreading habit.

M M 106: Belongs to Malling-Merton Series. The tree on this stock grows up to a height of 3.5 to 4.5 m. It is precocious with good anchorage and comes into bearing in 2 to 5 years, not adaptable to heavy and wet soils, highly susceptible to collar rot.

M 111: It is a vigorous stock, and tree on this stock grows up to a height of 4.5 to 5.5. m comes into bearing in 5 to 7 years, well adapted to all kinds of soils and is draught tolerant, moderately susceptible to collar rot, and does not sucker readily.

Planting

Choice of Plants

The following points should be considered for right selection of plant material:

- The nursery and the progeny orchard and mother plants should be examined.
- Plants should be free from insect pests and diseases.

— The plants should be one year old, strong, straight and with healthy roots.
— Graft union should be 20-30 cm above ground level.
— Graft union should be smooth and scion and stock girth should be almost equal.
— The plants should be of the desired and recommended variety.

Time of Planting

Apple like other temperate fruits is deciduous and sheds leaves in winters. Hence, the winter months i.e. December to February are the most suitable time for planting.

Spacing

In the slopy areas, contour terraces should be prepared before planting. For standard trees on seedling rootstocks spacing of 7 to 10 m should be maintained. The spacing can be reduced (3-4.5 m) when dwarfing rootstocks like M9 are used or for spur type varieties.

Digging of Pits and their Filling

Generally 1x1x1 m pit is dug for planting. But in rich and deep soils free from stones or rocks, the pit size can be smaller. While digging top-soil should be kept on one side and sub-soil on the other. The filling of pits should be done at least one month before planting i.e., in Novermber. The filling done with top-soil mixed with well rotted farmyard manure (40-50 kg per pit).

Planting

Planting should be done at least one month after filling. While planting the roots should be kept intact and properly spread out in a natural position. The graft union should be kept 25 cm above ground level. Before planting the nursery plants with bare roots should be sprayed or dipped in copper fungicide solution for destroying fungal disease organisms. For treatment against pests, particularly San Jose Scale and Woolly Aphid, a spray or dip in miscible oil emulsion or some systemic insecticide is recommended.

Irrigation of newly planted trees is necessary for getting a high survival rate. At some places winter rains and snow maintain the soil mositure adequately. Early planting should be preferred for better plant establishment. After spring growth starts, care should be taken to remove the weeds from the soil regularly and avoid dry spells either by irrigation or mulching. The shoots growing below the graft union or water sprouts up to 1 m height should also be removed.

Training and Pruning

The apple tree is trained to various systems depending upon the variety, rootstock used and enviromental and soil conditions favourng varied type of growth. In India, the most commonly used training systems are modified central leader system, and spindle bush system, the details of which are given below.

(i) Modified central leader system

Apple trees on seedling rootstocks are trained to modified leader system. A leader which develops on young trees is allowed to grow until it reaches the height of 2 to 3 m and then the growth is

restricted. During the first years, two to three primary scaffold branches, arising at proper angles, well spaced 10 to 15 cm apart and spirally arranged around the tree trunk are selected. Lowermost branch is selected at 30 to 60 cm above the ground level. Two to three secondary, scaffold branches are selected during the second dormant purning. During the subsequent years, traning consists of thinning out unwanted branches and cutting others to desirable side limbs.

(ii) Spindle Bush System

For growing apple trees on dwarf rootstocks the most popular and efficient system of training is spindle bush. In this system, tying of the scaffold branches during the first two years and heading back of the central leader are the most important operations. These branches are tied in August when extension growth ceases, to further restrict the growth and to increase the fruiting spurs. During the first winter pruning, 2-3 well spaced laterals are retained and the leader is also headed back to a weak lateral. In the subsequent years, branches are allowed to grow from the central leader at regular intervals.

Pruning of Bearing Trees

The primary consideration in pruning bearing trees is to maintain a balance between growth and production. It is well-known that excessive growth takes place at the expense of fruit production and that over production if allowed to go unchecked, results in weakening of the tree and loss of growth. The proper balance is reached when mature trees make about 20-25 cm of extension growth every year to increase the bearing area and maintain production. Mature apple tree requires a light thinning of the branches annually, so as to keep the centre fairly open to admit light. The upward tendency of branches should be checked by cutting, the severity of cutting back being in direct proportion to the vigour of the branch. The following points should be noted while pruning an apple tree:

- Start at the top of the tree and work downwards.
- Remove the crowding branches and thin the remaining, leaving the fruitng wood well spaced along the length of branches.
- Remove dead, broken and diseased wood.
- Remove all water sprouts except the ones which may be needed to fill a vacant space in the tree.
- Remove large limbs, if growing parallel and crowding other limbs.
- While removing a thick side branch, first cut should be made on the under side of the limb and then on the upper side.
- Thin out interfering branches growing upward from the top of the limbs.
- Divert branches to open areas by pruning back to desirable laterals.

Pruning of Old Trees

Old trees, bearing heavy crops of small sized fruit and making short extension growth, require to be pruned more severely than young trees. By heavy pruning new growth is encouraged and the vigour of fruit spurs is maintained.

Intercropping/Interplanting

In the initial years of planting up to 4 to

5 years of age, the apple orchard can be intercropped with crops like potato, cauliflower, cabbage, barley, peas, beans, etc. The leguminous crops like peas, beans or some other pulse crops are to be preferred. Care has to be taken that the crops do not compete with the main crop. After 4 or 5 years the intercropping should be stopped.

Orchard Soil Management

Clean basin management with permanent sod between the tree basins is the most common practice to conserve moisture, prevent soil erosion, keep the weeds under check and to maintain soil fertility.

Weeds in the tree basin should be kept under check either by regular hand weeding or with the use of herbicides (Gramoxone at 6 ml/1 litre water) in April and July. Care should be taken that the spray material does not come in contact with the apple trees.

The basins can also be covered with a suitable 15 cm thick mulching material like grass, oak or deodar leaves. Black alkathene mulch an also be used.

Green manure crops like sunhemp sunflower or soya bean can be grown and ploughed into the soil for improving its texture and nutritional status, especially in comparatively flat areas.

Manuring and Fertilisation

The young plants are given graded doses of fertilisers which are stabilised in the 10th year of age when the plant is considered to be fully grown. The dose of fertilisers is increased every year equivalent to the first years dose. The doses to be applied in the first year and in the tenth year are given below:

Age	*FYM (kg)*	*Nutrients (g)*		
		N	P_2O_5	K_2O
1 year	10	70	35	70
10 year	100	700	350	700

Farmyard and manure phosphorus and potash should be applied during December before snowfall. Apply half of the N in February-March before flowering and the remaining half in April after fruit set. The fertilisers should be broadcast all over the basin of the tree and mixed well in the soil.

Overcoming Nutritional Deficiencies

On some trees deficieny of nitrogen, zinc, boron, manganese and calcium may be observed. The major nutients like N,P,K should be applied through the soil whereas micro-nutrients are applied through foliage sprays. Where acute nitogen dificiency occurs, foliar application of urea (1 per cent) provides quick recovery. Foliar application should be given after petal fall as given in Table 17.2.

Irrigation

In general apple is grown in rain fed areas. If the irrigation facility is available, one or two irrigations per month can be given during the dry months of May and June. The drip irrigation method, although initially expensive, is very efficient so far as economy of water is concerned.

Flowring and Fruiting

The normal flowing period is from the last week of March to end of April. The

Table 17.2 : Foliar Nutrient Application Schedule for Apple Trees

Element	*Chemical used*	*Concentration (1%)*	*Frequency*	*Time*
Zinc	Zinc Sulphate	0.5	1-2 sprays at 15 days interval.	May-June
Boron	Boric Acid	0.1	1-2 sprays at 15 days interval.	June
Manganese	Manganese	0.4	1-2 sprays at 15 days interval.	June
Calcium	Calcium,	0.5	Two sprays at 15 days interval.	June-July

time of flowering and duration of flowering depend very much on the winter chilling. If winters are warm and mild, leading to low chilling, the flowering is delayed and poor resulting in low fruit set.

Most of the commercial varieties like *Royal Delicious*, *Red Delicious* and *Rich-a-Red*, are cross pollinated and need provision for polliniser varieties. Good pollinisers are *Tydeman's Worcester*, *Red Gold* and *Golden Delicious*. Recently crab apple and other wild species have been found to be good pollinisers. During flowering, if the climate is dry and mild with good sunshine and honey bees are available, the fruit set is good. Five honey bee colonies per hectare are considered to be essential. The population of polliniser trees may be 20 to 33 per cent.

Fruit takes about 110 to 150 days from flowering to harvest depending upon variety and environmental condition. The maturity of fruit is indicated by :

a. Ease in separation from the tree.
b. Change of ground colour from green to yellow.
c. Change of seed colour from cream to black.
d. Fruit firmness determined through pressure test.

Insect Pests and Diseases and Their Control

Insect Pests

The important pests of apple are dicussed below.

(i) San Jose scale

San Jose scale is the most serious pest. Less infested trees show small grayish speck on the dark surface. Severely infested trees have the bark covered with grey layer of overlapping scales and appears as if sprayed with woodash. The scale insect can be controlled by (i) dormant spray of 0.2 to 0.3 per cent diesel oil emulsion during February, (ii) by spray with insecticides like Chilophyriphos, Fenintrothion or Diemethoate, during summer.

(ii) Woolly Apple Aphid

The woolly apple aphid lives in colonies both on the root and aerial parts of the plant. On the aerial parts, it is seen as white woolly mass. Damage is caused by sucking of sap from stems, twigs and roots resulting in gall formation. Affected plants remain stunted with greatly

reduced fruit bearing capacity. Application of Phorate granules at the stem collar during April and October and summer sprays as recommended for San Jose scale give effective control.

(iii) Defoliating and Fruit Eating Beetles

Many phytophagous species of beetles attack, practically all temperate fruits. Beetles appear in May-June and feed on foliage and developing fruits at dusk. Control measures include spray of Methyl parathion at 0.05 per cent or Carbaryl at 0.1 per cent, in May and June.

(iv) Borers

These cause damage to roots, stem and shoots of apple and pear as a result of which plants become weak or dead. Due to shot hole borer, shot hole like perforations appear on the main trunk and branches followed by sickly appearance of the tree Control measures include treatment with Aldrin at 5 per cent of BHC 10 per cent dust at 200-300 g per tree. For shoot borers, cleaning the hole made by the borer with a wire and insertion of cotton soaked in petrol or methyl parathion and plugging the hole with mud has been found effective.

Diseases

(i) Apple Scab

This disease is caused by fungus *venturia inaequalis.* Scab symptoms appear on the parts above ground particularly the foliage and fruits. Light brown or olive green spots which soon turn musty black, appear on either or both sides of the young leaves in spring. Severe spotting leads to premature leaf drop and severe early infection results in the formation of misshapen fruits. Fissures of cracks after they develop in scabbed areas allow the entry of other organisms and causes rot of the fruit. Apparently healthy fruits which get infected in late summer (monsson) develop a small rough, black, circular lesion on their skin, during storage. The disease is controlled by (a) spraying at silver tip stage, with Captafol or Dodine, (b) spraying at petal fall stage, with Carbendazin, and (c) at fruit development stage, 2 to 3 sprays of Captan, Diathane M-45 or Captafol.

(ii) Powdery Mildew

Powdery mildew is caused by fungus *Podosphaera leucotricha.* The disease affects the growth of buds, new shoots and leaves and produces white powdery patches. Fruits of certain varieties show rusetting. Control measures include (a) Pruning off silver terminal, (b) spraying after dormancy at bud swell, at petal fall and two weeks later wtih wettable sulphur or Carbendazine or Karathane.

(iii) Hairy Root

The malady is caused by *Agrobacterium rhizogenes.* Excessive growth of fibrous roots originate frrom one place and present broom like appearance. Control measures include (a) avoding injury to roots or the collar, (ii) dipping healthy grafted plants in 1 per cent copper sulphate solution for 1.5 hours before planting.

(iv) Crown Gall

When infected by *Agrobacterium tumefaciens* the plants produce globular, elongated or irregular tumours at or

near the graft union mainly in nursery plants. Control measures are the same as for Hairy root disease.

(v) Canker and Dieback Diseases

A number of bacteria cause these diseases. Canker diseases develop different types of symptoms on trunk and branches. Cankers usually start from an open wound and produce either deep sunken brown lesions or erupted black lesions on the bark. The bark turns papery and the portions above or below the canker get killed. Control measures include (a) cutting and burning the badly cankered portions of the tree. (b) applying *Chaubatia* paint or copper oxychloride on the wounds. (c) spraying copper oxychloride, and (d) spraying schedule for apple scab can also control cankers.

(vi) Virus Diseases: (Apple Mosaic, Little Leaf, Leaf Pucker, Chlorotic Spots, Star Cracks)

Virus produces mosaic symptoms on leaves, curling, puckering, reduction in leaf size; reduction in vigour of the trees, and excessive proliferation of buds and thereby reduction in fruit production. To check the attack of virus diseases the use of graft wood from infested trees should be avoided.

(vii) Rubbery Wood (Mycoplasma like Organism)

The disease causes rubberiness and fall of shoots. The affected tree ramains stunted. To check the attack of this disease, the use of graft wood from infested trees should be avoided.

(viii) Lichen (Algal and Fungal Symboints)

Various coloured radiating growth of lichen appear on portions of the tree. The control measures include (a) spraying of 1 per cent caustic soda on affected trees, (b) application of tree spray oil as for the control of San Jose scale.

Integrated Spray Schedule for Apple orchard

(Based on control of apple scab as a principal disease)
Note: Chemicals are for 200 litres of water

(i) Late Dormancy (Late February to early March/2-3 Weeks before Bud Burst)

Hindustan Petroleum Tree spray oil E (AL) plus Fenintrothion 0.05% (200 ml Sumithion/Folithion/Accothion) or Chlorophyriphos 0.04% (400 ml Danusban/Ruban 20 EC). This mixture is for the control of San Jose scale, caterpillars, sucking insets including woolly aphids and thrips.

(ii) Bud Swell to Green Tip Stage (March-April)

Captofol (600 g) or Mancozeb (800 g) or Dithinanon (150 g) or Dodine (200 g). For powdery mildew, wettable sulphur (300 g) to be mixed with Mancozeb (250 g). Against collar rot, tree basins to be drenched with Mancozeb (300-400 g/ 100 water) or Copper oxychloride (500-1000 g/100 k,water). Against woolly aphid, Phorate 25-30 g or Thimet 10 g or Aldicarb 25-30 g or Temic 10 g per tree to be applied around the tree trunk 5 cm

below soil level at the petal fall stage to restrict the upward movement of woolly aphid crawlers.

(iii) Pink Bud Stage (April)

Mancozeb (500 g) + Wettable sulphur (500 g) or Bitertanol (200 ml Sumithion/ Folithion/Accothion) or Monocil 36 WSC). These chemicals are effective for protecting trees from primary scab infection. The insecticides also give effective control of blossom thrips.

(iv) Petal Fall Stage (April-early May)

Carbendadzim (100 g) or Mancozeb (600 g). If scab lesions are visible, a mixture of 500 g Mancozeb and 50 g Carbendazim fungicides, shold be used.

(v) Early Fruit Development Stage (Late May-June)

Mancozeb (600 g) or Dithianon (100 g) plus Chlorophyriphos 0.04% (400 ml Danusban/Ruban 20 EC) or Fenintrothion 0.05% (200 ml Accothion/ Folithion/Sumithion 50 EC). This spray controls scab and cankers, crawlers of San Jose scale and Woolly aphid. For control of caterpillars and defoliating beetles, Carbary 10.1 per cent (400 g Sevin 50 WP) jor Methyl Parathion 0.05 per cent (200 ml Metacid 50 EC) shold be mixed.

(vi) Late Fruits Development Stage (Late June-July)

Mancozeb/Captan/Dithianon alone, to be repeated.

(vii). Pre-harvest (20-25 days Before Harvest

Captafol (300 g) or Mancozeb (600 g) plus Carbaryl 0.05% (200 g Sevein 50 WP) Malathion 0.05% or (200 ml Cythion 50 EC).

It controls leaf spots, cankers, fruit spots, scab and fruit rots and enhances storage life of fruits. Addition of insecticides take care of leaf folding and fruit scrapping caterpillars.

(viii) Post-harvest Stage (October)

Chlorophyriphos 0.04% (400 ml Danusban/Ruban 20 EC) or Fenintrothion 0.05% (200 ml Sumithion/ Folithion/Accothion 50 EC).

This spray controls above ground woolly aphid, leaf minor and other insects feeding on leaves (spray only if required).

Against collar rot, tree basin should be drenched with copper oxychloride (500-1000g/100 1 water).

Against woolly aphids, band treatment to be repeated (refer to second spary) if required. This application should be made by the end of October to middle of November.

(ix) Pre-Leaf Fall Stage (November)

Application of urea at 5 per cent should be done to increase the fruit set. This spray disrupts the lifecycle of scab fungus and accelerates decomposition of fallen leaves. Collect and destroy the fallen leaves.

Harvesting, Yield and Post Harvest Handling

The exact time of harvesting, which varies according to the variety, season, location, etc., is often difficult to determine. It picked early the quality is low, and if picking is delayed there is breakdown of

flesh and the keeping quality is impaired. For distant markets, picking should be done in advance of full maturity, whereas for the home market, the fruit may be allowed to remain on the tree until it is properly ripe.

Most of the varieties when ready for picking can be easily removed from the spurs. The fruit should be removed from the spur rather carefully by grasping it in the palm of the hand and then giving it an upward twist of the wrist. A straight pull will injure the skin in the cavity and make the fruit mouldy if kept for long.

Although, the yield may differ depending upon the variety and type of rootstock used and plant density, however, on an average a yield of about 5-6d tonnes per hectare may be obtained.

Grading and Packing

There are seven size grades of apples the details of which are given in Table 17.3

Each fruit is wrapped in paper according to its grade. The wooden box is lined with old newspaper sheets keeping the margins overhanging the flaps. The fruits are initially padded with wood wool/pine needles at the bottom and later between intervening layers. Paper wrapped fruits are arranged in each layer and the top layer is covered with paper by bringing together the overhanging flaps. Then the top is nailed. In recent times cardboard boxes of 20 and 10 kg capacity have also become available and are fast replacing wooden boxes. In such boxes, trays are also being used.

Storage and Extension of Shelf-life

The apple fruit is stored in cold storage at 1.1 to 0°C with 85 to 90 per cent relative humidity for four to eight weeks.

Special Problems

(i) Pre-harvest Fruit Drop

In apple, there are three distinct stages of fruit drop. (a) early drop, resulting from unpollinated or unfertilized blossoms, (b) June-drop, and (c) pre-harvest drop.

The problem of pre-harvest drop is more severe in early cultivars where 40 to 60 per cent of fruits drop. In the mid-season cultivars viz., *Red Delicious, Royal Delicious* and *Golden Delicious*, the pre harvest drop is about 15 to 20

Table 17.3 : Grades of Apple Fruits

Grade	*Fruit diameter (mm)*	*Box size inner dimensions (cm) L x B x H*	*Size of wrapping paper (cm)*	*No. of layers*
Super Large	85	45.7 × 30.5 × 27.9	27.9 × 27.9	3
Extra Large	80	45.7 × 30.5 × 25.4	25.7 × 26.7	3
Large	75	45.7 × 30.5 × 30.5	25 4 × 25.4	4
Medium	70	45.7 × 30.5 × 27.9	24.1 × 24.1	4
Small	65	45.7 × 30.5 × 25.4	22 5 × 22.8	4
Extra Small	60	45.7 × 30.5 × 25.4	21.5 × 21.5	4
Pittoo	55	45.7 × 30.5 × 25.4	Not wrapped	Loose

per cent. To control pre-harvest drop, spraying of NAA at 10 ppm is most effecivie. The spray should be done about a week before the expected drop.

(ii) Imporvement of Surface Colour and Enhancement of Maturity

Apple surface colour development is greatly hampered in low lying areas due to warmer conditons. Such fruits fetch a poor price. At very high altitudes, the maturty is delayed thus delaying the harvest. Application of ethrel at 1,200 ppm improves the colour in mid hills and enhances maturity in the high hills. The spray of freshly prepared solution should be done about a week before the expected harvest time. NAA at 25 ppm should be added to ethrel. Since the ethrel treatment impairs the storage life of fruit, the treated fruit should not be put in cold storage.

(iii) Fruit Thinning

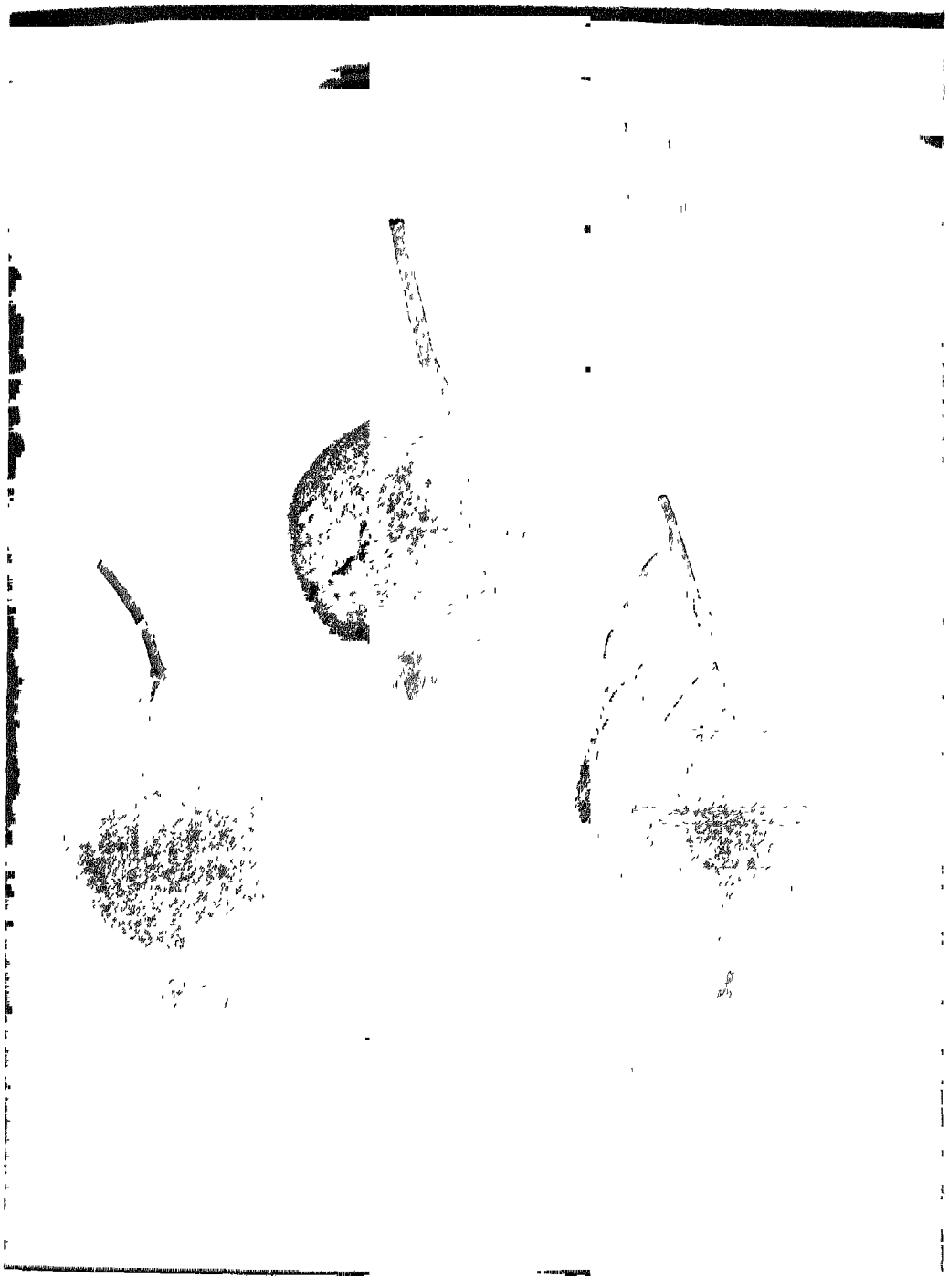
Heavy bearing in many apple varieties results in smaller, low quality and unmarketable fruits, and limb breakage. Thinning of fruits tend to maintain tree vigour and regular production of quality fruits. In beinnial bearing varieties, the thinning programme during 'one year' should be done in order to obtain regular bearing. Application of 10 ppm NAA, 5 to 15 days after petal fall or when average fruit length is about 15 mm is most effective. Carbarly (Sevin) at the rate of 0.075 per cent applied 7 to 10 days after petal fall is effective for fruit thinning in apples.

(iv) Hailstorm Damage

Most of the apple growing areas of the country are prone to hailstorms. Hailstorm at flowering time results in flower drop and hinders effective cross-pollination as a results of which fruitset is reduced. Hailstorm at fruit development stage results in direct injury to the fruit and also causes fruit drop. Severe hailstorm also results in spur and limb breakage thus causing permanent losses and reducing the productivity of trees over a number of years. Only effective method of saving the crop and trees from such damage is to cover the trees with nylon nets during the hailstorm period.

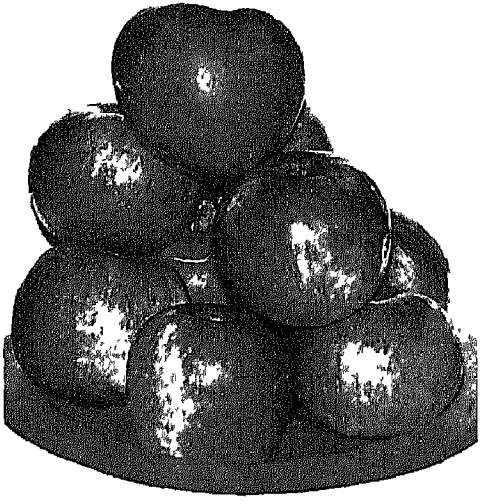
QUESTIONS

1. Enumerate the apple varieties into (i) Standard varieties, (ii) Spur type, and (iii) Low chilling type.
2. Explain the procedure for raising the 'Clonal rootstock' and also list some of the clonal rootstocks along with charactersties useful in apple production.
3. Why is training and pruning in apple production necessary? Discuss the different training methods followed in raising apple orchards.



Pomogranate (Variety- Bassein Seedless)

APPLE VARIETIES



Tyman's Early Worcester

Royal Delicious in Bearing

Gloden Delicious in Bearing

Vance Delicious in Bearing

Bearing of Pear (Variety-Sand Pear)

Bearing of Peach

4. Write short notes on:
    i. San Jose scale
    ii. Crown gall
    iii. Spur
    iv. *Goldlen Delicious*
5. Explain the following:
    i Flowering and fruiting
    ii. Maturity symptoms
    iii. Fruit thinning
    iv. Improvemnt in fruit colour and enhancement of fruit maturity

CHAPTER 18

Pear

Introduction

The (*Pyrus communis* Linnacus) is a good source of carbohydrates and minerals Fruits contain vitamins A, B_1, B_2 and small quantities of vitamin C. The fruit is refreshing and tasty.

Origin and Distribution

The primary centres of origin of pear are Asia Minor, Caucasus and Central Asia. It is adaptable to a wide variety of climatic conditions. Major pear producing counties are:

N.America	:	U.S.A., Canada, Mexico
S.America	:	Argentina, Brazil, Chile
Europe	:	Italy, former U.S.S.R. countries, Germany France, Switzerland, Spain, Austria, Poland, Greece, Bulgaria, Holland.
Asia	:	Japan, Korea, and China
Others	:	Australia, New Zealand and South Africa

In India, pears are grown in Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh, Arunachal Pradesh, Meghalaya, Mizoram and Nilgiri Hills and Kodaikanal in Tamil Nadu.

Subtropical pear varieties are grown in the plains of North India mainly Punjab.

The cultivated pears are derived from two sources, the European (*Pyrus communis* L.) and the oriental (*Pyrifolia* var. Culta).

Botany

Pears belong to the family Rosaceae, sub-family Pomodeae and genus *Pyrus*. The pear tree is tall, deciduous, upright growing and sometimes thorny. Buds are conical and covered with scales. Flowers are white and rarely pink. Fruit is pome, pyriform or globose, with persistent calyx.

The European pear is different from the oriental pear which has deciduous calyx, nonfleshy pedicels and apple shaped fruit.

One of the species of pear named as *mehal P. pashia*, is found growing wild in the Himalayan region. This species has been used as rootstock for many of the cultivated varieties.

Area and Production

Amongst the hill states of northwestern India only Jammu and Kashmir has a

sizable area under pear aeltivation. This state had an area of 3.179 hectares under pear in the years 1987-88 with an annual production of 960 tonnes. Thus indicating extenely low productivity i.e., less than 1/3 a tonne per hectare. This speaks of the reason for the pear being largely ignored in other hill states in preference to apple. As compared to this, the subtropical pears (variety Sand Pear) grown in Punjab on an area of 6,638 hectares with a production of 1,65,000 tonnes has an average productivity of around 25 tonnes per hectare. This production level indicates good adaptability of such pears under subtropical areas, but because of very low fruit quality and marketing problems no further significant progress in this respect is expected. The only solution, therefore, lies in improving the uality of subtropical pears or to find ut temperate varieties which can give better yields in the hill areas.

Climate

The pear can be grown from the foothills to high hils (600 to 2,700 m above sea level) with a range of chilling hours from 500 to 1,500. It thrives best in areas which are located on northeastern aspect at lower elevations and on southwetern aspects at higher elevations. spring frosts cause extensive damage to the blossoms which are killed below 3.3° C. The sand pear thrives even in ares with 250 to 300 hourse of childing.

Soil

The pear gros best in deep, medium texured and well drained soils. The pears can also do reasonble well where the soil has a high water table, is poorly aerated or too heavy in texture for other deciduous fruit plants. For proper root growth and development there should not be hard rock or pan at least two metres of soil depth.

Varieties

Some of the important high hils, low hills and valley area varieties are shown in the table given below.

Following is a brief description of important varieties:

Early China: A very early ripening variety; fruit size is small, roundish, ripens in June.

High hills varieties			*Low hills and valley area varieties*
Early	*Mid season*	*Late*	
Early China	*Bartlett*	*Doyenne Comice*	*Pather Nakh*
Laxton's Superb	*Conference*	*Easter*	*(Sand Pear)*
Fertility	*Sparking Delicious*	*Beurre Hardy*	*Kieffer*
Seckel	*Max-Red bartlett*	*Winter Nellis*	*China Pear*
	Dr. Jules Guyot	*Clapps Favourite*	
		Flemish Beauty	

Laxton's Superb: Fruit size is variable, shape unequal oblong pyriform; skin rough, thin, yellowish green; flesh light yellow, crisp, juicy, sweet; flavour pleasant, good quality. Tree is medium

in vigour, growth upright, hardy and productive.

Fertility: Fruits are round, conical, a little lopsided; skin rough, pale yellow, largely covered with brown russet and dots; flesh white with a yellowish tinge, juicy, sweet, fair flavour; tree moderately vigorous, upright habit, heavy cropper.

Bartlett: Popularly known as *Bagu Gosha* in Kashmir. It is a most popular commerical variety; the fruit is large in size, oblong-obtuse-pyriform, tapering towerds apex; skin thin, tender, smooth; colour clear yellow; flesh fine grained although slightly granular at the centre, melting, very juicy, aromatic, quality very good; tree medium in size and productive; suitable for canning and drying.

Conference: Fruits are medium size, pyriform in shape; skin green changes to pale yellow on maturity; flesh creamy white, a pinksih tinge, melting, very juicy, sweet, pleasant flavour; tree moderately vigorous, fairly upright and rather spreading.

Sperking Delicious: Fruits are pyriform, extra large; colour golden yellow blushed red; flesh white, juicy and delicious to eat; tree vigorous.

Dr Jules Guyot: Fruits are large, oblong-obtuse-pyriform; skin very thin and tender, colour yellow, more or less mottled and with traces or russet, with a red blush on the exposed cheek; flesh yellow hite, granular, tender, moderately juicy, sweet, aromatic, quality good. Tree is medium in size, vigorous, upright, hardy and productive. It is a regular bearer. Fruit ripens in August.

Flemish Beauty: Fruits are large, uniform in size and shape, roundish or ovate-obtuse-pyriform, colour clear yellow, spread over on the exposed cheek with a dotted and marbled red blush; flesh tender, granular, juicy, sweet, aromatic with a slight musky flavour and very good quality. Tree is medium in size, vigourous, spreading with drooping branches, hardy and productive. Fruits ripen in Septmeber.

Doyenne Du-Comic: Fruits obvate-obtuse-pyriform or roundish: skin rough and granular smooth, yellow except for russet markings with a very faint russet red blush; flesh tinged strongly with yellow, fine grained, metling, tender, buttery, very juicy, sweet and aromatic. Tree is vigorous, upright, dense and usually productive. Fruit ripens in October.

Winter Nellis: Fruits are uniform in size and shape, roundish, ovate-obtuse-pyriform, russeted; colour yellow with a tinge of green dotted with grayish russet streaks and patches on the exposed cheeks which is usually blushed with bright red. Flesh is yellow white, quite granular, tender, melting, buttery, very juicy, sweet, aromatic and with good quality. Tree is medium in size and vigour, spreading, hardy and very productive.

Pathar Nakh (Sand pear): Fruits are round, medium in size with yellowish-green surface colour with white dots., Flesh is white, texture gritty and granular. Tree is spreading and vigorous. ripens in the last week of July in the plants.

Kieffer: Fruits are large, pyriform and with golden yellow colour. Flesh is juicy, often gritty and of poor quality. It is very good for culinary purpose.

Leconte: Fruit is small to medium in size and pyriform in shape. The skin colour is greenish yellow. Flesh is whitish, juicy and sweet. It ripens by the end of July. Tree is medium in vigour and spreading.

Propagation

In general *P. pashia (Kainth* or Himalayan pear) or *P. pyrifolia* seedlings are used as rootstocks. Pear suckers are also used as rootstocks especially in the plain areas. Qunice-A (*Cydonia oblonga*) can be used as rootstock to produce dwarf plants. The desired varieties can be grafted in February-March in the hills and in January-February in the plains on the rootstocks by tongue grafting or by 'T' budding in rainy season. Sand pear is also propagated by cuttings.

Raising of Nursery Plants on Seedling Rootstock of *Kainth*

Seeds of *Kainth* are collected locally in the hills and sown in the field without stratification during December-January. For better germination, seeds of *Kainth* may be stratified in moist sand for 35-45 days at 2-5°C before sowing. One year old seedlings are used for grafting, and tongue grafting is done during February-March. T-budding during June-July can also be done.

Characters of Main Rootstocks

Kainth is deep rooted, resistant to drought, semi-vigorous.
***Shiraa (P. serotina* Reha)** trees are more vigorous in comparison to Kainth.

Characters of Clonal Rootstock

Qunice-A: It is a semi-dwarf and produces trees of standard size up to 50 to 60 per cent. However, this rootstock has poor compatibility with most of the commercial varieties. Incompatibility can be overcome by double grafting with Beurre Hardy.

Planting

All the planting operations are similar to those of apple in respect of choice of plants, time of planting, digging and filling of pits, planting and after care.

The planting is done during December to March. The plant to plant spacing should be 6 to 8 metres on seedling rootstocks. The spacing can be reduced to 3-4 m for dwarf plants on Qunice rootstocks.

Training and Pruning

Pears are more upright-growing than apples. They can be trained to the form of pyramids, bushes, espaliers and cordons. Pears on pear stock makes vigorous growth and develops into large tree. Such plants are also are trained on the modified centre leader or central leader system like apple and the steps are trained on the modified centre leader or central leader system like apple and the steps in training such trees are the same as in case of apple. On Qunice stock, the tree remains dwarf and is usually trained as a pyramid, cordon, espalier, etc.

To train trees into the pyramid form, the one-year old plant may be cut at about 75 cm from the ground. This would force the growth of four to five shoots on the stem in the following summer. The leader is pruned to about 25 cm in the second winter and the laterals to about 20 cm to the upward pointing buds. In the second summer, all the branch leaders and laterals should be pruned to five or six leaves from the clusters, allowing the central leader to grow unchecked. In the third winter, the central leader is cut back to about a

third of its length, but the branch leaders and laterals are not pruned. In the third summer, the branch leaders and laterals are again cut back to five to six leaves as during the previous summer. In the fourth winter, the central leader is again cut back to a third of its length. By following this procedure, pear tree on Quince rootstock would start flowering in the fourth year.

Pruning of Bearing Trees

The same rules apply to the pruning of bearing pear trees as are described for apple. The trees should be kept in vigorous condition so as to be able to make yearly extension growth of about 25 cm. In case of mature trees, a light but well distributed pruning is essential to admit light and sun to all the fruiting wood. In case of old and bearing trees, pruning of dead wood and non-bearing spurs should be done. The thinning out and heading of laterals may also be done to encourage the formation of more fruiting spurs.

Intercropping and Interplanting

Intercropping of pear orchards is similar to those of apple orchards.

Manuring and Fertilisation

The fertiliser and manurial requirements of pear have not been specifically worked out, but a similar schedule like that of apple is recommended. A ten year old mature tree requires 100 kg FYM, 700 g N, 350 g of P_2O_5 and 700 g of K_2O. The younger trees need graded doses like that in apple. Pears are sensitive to boron deficieny which can be corrected by 0.1 per cent spray of boric acid in April-May.

Irrigation

In general pears are mostly grown in the hills under rain fed conditions. Wherever facilities are available, two to three irrigations during April to June at monthly intervals are sueful. In plain areas, in addition to these irrigations some more irrigations are also required if the monsoon rains are not regular.

Flowering and Fruiting

Flowering in pear occurs in March-April. In the hills, spring frosts during flowering period appreciably reduces the fruit set as in the case of apple.

Most of the pear varieties (with the possible exception of *Bartlett*) are self unfruitful. They, however, produce plenty of pollen and any two varieties overlapping during the blooming periods will pollinate each other. *Pather Nakh* variety bears abundant crops in the plains when grown by itself, since it is a self-fruitful variety.

The criteria for determining maturity of pears are; colour change, change in firmness of flesh, change in T.S.S. and ease with which the fruit can be separated from the spur by upward twist. The number of days from flowering to maturity are almost constant for a variety. The optimum time of harvest for *Bartlett* pears grown under Kullu Valley conditions has been found to be 122 days from full bloom, i.e., the second week of August.

Insect Pests and Diseases and Their Control

Insect Pests

The mjaor pests of pear are; Woolly aphid, blossom thrips and root and shoot borer.

Diseases

The important diseases of pear are, hairy root, crown gall, collar rot, leaf spot, root rot and powdery mildew.

Pears are generally less susceptible to pests and diseases as compared to apple. Control measure for different pests and diseases are the same as in the case of apple.

Harvesting and Yield

Pears should be picked while still green as they are highly perishable. Care should be taken to pluck the stalk with the fruit. When the pears appear to attain full size, lift the fruit by the palm and give a twist to the stalk with the thumb and first finger. The fruit should come off the spur easily. While harvesting care should be taken that no part of the spur is removed since breaking of spurs will affect next years crop.

The yield is greatly influenced by the variety, age of the plant, orchard management and the prevailing climatic condition. However a well managed orchard on an average may yield about 30-40 tonnes of fruits per hectare.

Handling and Storage

After harvest the heat of the fruit should be reduced quickly with cool air flow or refrigeration. This process is called precooling which is essential for satisfactory storage.

The fruits can be packed in wooden or cardboard boxes of 10 kg or 20 kg size. A storage temperature of less than 0°C with 85 per cent relative humidity can maintain shelf-life of fruit for two to three months.

Questions

1. How is pear propagated commercially? What are the characteristics of the rootstocks and propagation methods.
2. Discuss the training and pruning methods followed in pear cultivation.
3. Write short notes on:
   i. Storage of pears.
   ii. Nutritive value.
   iii. Maturity indices.

CHAPTER 19

Peach

Introduction

Peach (*Prunus persica*) fruits are rich sources of minerals especially iron and vitamins A and B. Vitamins B_{12} and C are also present in traces. Peaches are used as a table fruit and for canning as peach halves and slices.

Origin and Distribution

Peach originated in China where it was known to grow as far back as 2000 B.C. Peach is primarily grown in temperate zones between 20 and 40° North and South latitude. Some varieties can be grown in subtropical or tropical zones at higher elevations.

Major peach producing countries are the United States of America, France, Italy, Spain, China, Japan, Argentina and South Africa.

In India it is grown in Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh hills, Nilgiri hills and in submountanous and plains of Noth India including Punjab, Haryana and Uttar Pradesh.

Botany

Peach belongs to the family Rosaceae, sub-family Prunoideae and genus *Prunus*. The cultivated species is *Prunus persica*.

Peach is a small tree, flowers are solitary and pink. The leaves are oblong, lanceolate with serrated margins. Fruits are of variable size and shape and are pubescent.

Area and Production

The world production of peach in 1981 was 7.5 million tonnes. The United States of America and Western Europe contributed 70 per cent of the world production. In India the estimated production is around 20,000 tonnes annually.

Climate

Peaches do well in wet and humin climate with cold winters and warm summers. The chilling requirement of temperate varieties is approximately 750-800 hours below 7° C in winters. However, there are a large number of varieties requiring low chilling of 200 to 500 hours and are grown in the subtropical areas. Annual rainfall of 45 cm without summer draught spells is sufficient. Peaches can be grown successfully in the lower and mid-hills between 1,000 to 2,000 m above sea

Mid hills varieties			Low hills and plain area varieties
Early	Mid season	Late	
World's Earliest	Alton	J.H.Hale	Florida Sun
Early White Giant	Kanto-5	July Elberta	Shane-e-Punab
Red Haven	Shimizu		Florida Red
Sun Haven			Sharbati
			Kurmani

level. A large number of Florida peach varieties and some locally selected varieties are grown in the plains because of their low chilling requirements.

Soil

Peach thrives on a wide range of soil types but does best. on light, gravelly and clayloam soils which are fertile and deep. Good drainage is very essential.

Varieties

Some of the important mid hills, low hills and plain area varieties are described below

World's Earliest: Fruit is small to medium, shoulder even, suture distinct; flesh cream colour, juicy, clings to stone, taste acidic, ripens in third week of June.

Early White Giant: Frut is medium to large, free stone; flesh sweet and most appealing in flavour; good bearing quality.

Red Haven: Fruit size is medium, round, suture prominent; skin yellow, overlaid red to deep red, attractive, tough, pubescene light to medium; flesh yellow red at pit, very firm, melting, quality good; pit large, usually free when ripe; ships very well, ripens very early, about 30 days before *Elberta* during early June.

Sun Haven: Fruit is medium to large, nearly round, uniform; skin very attractive, flesh yellow, free stone when fully ripe: ripens in first week of July.

Alton: Fruit is medium, roundish, pulp clings to stone, colour yellow, skin hairy, subacidic in taste, ripens in third week of June.

July Elberta: Fruit is medium in size, skin dull red, blushed and streaked on greenish yellow ground, pubescence heavy and dense; flesh yellow only slightly red at pit, firm, melting, very good quality; matures in the second week of July.

Kanto-5: Matures in the first week of July; trees are vigorous, fruit large sized; red coloured with yellow background like *July Elberta;* flesh yellow, clings to stone, flavour excellent; T.S.S. 13.5 per cent.

Shimizu Hakuto: Matures in the second week of July; trees are dwarf and spreading; fruits are medium sized, quite firm, roundish, red blushed or creamish background, quite tasty; T.S.S. 18 per cent; flavour excellent; flesh white, clings to stone.

J.H.Hale: Fruit is medium, roundish, ovate; colour red purple yellow; sub-acidic in taste, free stone, ripens in third week of June.

Florida Sun: The tree is vigorous; earliest to ripen by the end of April; fruit is medium to large, roundish, yellow with

a red blush; the flesh is yellow, juicy and sweet.

Shan-e-Punjab: Maturing in the first week of May; tree is vigorous in growth; fruit is large, yellow with red blush, juicy and sweet with excellent taste; flesh yellow and completely freestone; fruit quite firm in texture and can withstand transport.

Florida Red: An excellent mid-season table peach maturing in the beginning of June; tree is vigorous; fruit is large, almost red at maturity, juicy with soft white flesh; freestone.

Sharbati: The tree is spreading and vigorous; fruit is large, greenish yellow with rosy patches, very juicy with excellent taste an flavour; ripens in the first week of July.

Khurmani: The tree is medium in vigour and upright in growth; fruit is large, attractive with red colouration, slightly pointed at the base; flesh is white soft, juicy and is clings to stone; ripens in the first week of July.

Propagation

Peach is propagated by budding on peach seedling rootstock Peach seedling rootstock succeeds best in high, deep and drained soils. In the hills, mostly wild well peaches are used as seed source to raise rootstocks. In the plains, however, seeds of *Sharbati* and *Khurmani* are mostly used for raising rootstocks. In heavy and water logged soils, plum does well as a rootstock although not all plums are compatible with peach. The clonal rootstocks can be raised by cuttings or by mound layering. The scion varieties are propagated by grafting or budding. In the colder temperate zones tongue grafting is successful, whereas in warmer and sub-tropical areas 'T' budding can be adopted.

Planting

All the planting operations in peaches are similar to apple. The spacing of plants is normally 6 m apart each way. Planting is done in winter when the plants are young up to middle of January in plains, and up to end of February in the hills.

Training and Pruning

Peache are usually trained to open-vase system or open centre. Soon after planting the stem is cut at a height of 60-80 cm from the ground and only 3 to 4 branches are allowed to develop on it. These main branches should be well-spaced and distributed on all sides and not lower than 50 cm height from ground level. Shoots other than the selected ones, should be rubbed off during the first summer. This process is repeated twice of thrice to allow the selected shoots to provide wide laterals and make proper growth.

During the second summer, forked branches are cut unequally to make strong crotches. In pruning the cut is made always in a manner to encourage a spreading shape.

Annual pruning of bearing trees is necesssary to maintain open centre with a view to admit light which is essential for the satisfactory development of the colour of fruit and to prevent fungus disease and stimulating strong new wood for crop production. Peach bears fruit mostly on one-year old wood and its pruning is of importance. The best rule for thinning is that only 3-4 main limbs each having two secondary branches be

allowed to develop. Heading back is done annually. In heading back, the one-year old shoots are pruned back to two-thirds of their length and some are thinned out. Cut is made so that the lateral branches point outwards to encourage a spreading growth. In the plains of north India pruning is manipulated to produce at least 50 to 100 cm growth in young trees and 30 to 70 cm in old tres.

Interculture and Intercropping

Shallow intercultivation in winter during April-May between rows is essential to check the weed growth. After fruit harvest, suitable crops preferably leguminous crops may be grown in the monsoon season which can also be used as green manure.

Application of Manures and Fertilisers

The peach is a heavy feeder as compared to other stone fruits and needs more nitrogenous fertilizers. Amount of fertilizers depends on the type and ferti.lity of soil.

While one year old plant is given 10 kg of FYM, 50 g N,25 g P_2O_5 and 60 g of K_2O, a mature peach tree of 10 years age needs to be supplied with 60 Kg FYM, 500 g N, 250 g P_2O_5 g and 600 g K_2O. The adult doses is gradually reached through annual increase with increase in the age of the plant, the quantum of increase being equal to the dose given to a year old plant.

Farmyard manure, P_2O_5 and K_2O may be applied during December-January. Nitrogen is applied in split doses, half N in spring before flowering and other half a month later.

Irrigation

Where irrigation is available, it should be applied regularly fter fruit set and till the crop is harvested. This helps in getting bigger sized fruits. Where irrigation water is not available, conservation of moisture is very important. This is done by mulching with dry grass or hay 10-15 cm in thickness, spread evenly in the tree basin. Even in irrigated areas mulching helps in reducing the frequency of irrigation and hence economy in the use of water.

Irrigation should be continued at somewht longer intervals afte the fruit is harvested. The importance of this fact is not generally realised. Extermely dry soil conditions after harvest result in early leaf fall, which in turn adversely affects the fruit bud formation. The shedding of flowers and young fruits in the following year is also increased.

Flowering and Fruiting

Flowering ocurs at the end of February extending into March. Like any other temperate fruit crops, hailstorms or spring frosts during this period cause injury to the flowers and thereby reduces the crop.

Most of the peach varieties are self-fruitful excepting *J.H. Hale*, which is self-unfruitful. This variety can be pollinated by any other peach variety. Most of the varieties set heavy fruit and tend to over produce, resulting in smaller fruit. To obtain larger size, fruit should be thinned, keeping 10-15 cm distance between the fruits. Good blossom thinning can be obtained by spraying Ethephon 300 ppm. Thinnng is also recommended after the natural drop, if

the crop is still heavy, in May and June for the development of proper fruit size and good quality.

It takes about 70 to 110 days from flowering to harvest according to variety.

Insect Pests and Diseases and their Control

Insect Pests

(i) Peach Leaf Curl Aphid

Leaves acquire a characteristic curling as a consequence of sucking of sap from the growing buds. Floral buds also become weak and result in poor setting and fruits fall off prematurely. Major attack is during pre-bloom and blooming period.

(ii) Blossom Thrips

Besides apple, thrips also attack plum, peach, apricot, cherry and almond.

(iii) Peach Fruit-fly

Fruits affected are peach and apricot. Flies lay eggs on fruits and feed on the pulp. Soon the rot starts and the fruit is rendered unfit for consumption. Pupation takes place in the soil under untreated trees at 2-7 cm depth.

(iv) Scales

In addition to peach, plums are also affected, Small nodule like brown colured female bodies of the scale are observed on current growth of the tree. Large number of flies and ants get attracted due to the honey dew secreted by them. Heavy attack of the pest may result in poor fruit set or under sized fruits,

(v) Borers

The are several borers which attack peaches and other stone fruits like plum, apricot, almond, cherry, etc. They bore into the stem or shoots. The plant becomes weak or dies in case of severe infestation. The above ground borers are evident from the drying up of the terminal shoots.

(vi) Defoliating and Fruit Eating Beetles, Bark Eating Caterpilars

Incidence of bark eating caterpillars on stone fruits is increasing in mid and foothill areas. Caterpillars feed upon the bark as well as on the stem.

(vii) Nematodes

Root-knot nematodes are responsible for making knot-like agalls which lead to malfunctioning of roots. The above ground parts of the plants show stunting and yellowing of leaves. the infected roots are darkened in colour. Plant growth is patchy in th nurseries. The other nematode species causes bunching of fibrous roots resntting in stunting of plants and reduction in fruit yield. In addition to peaches, other fruits affected by these nematodes are plums and almonds, For peach, nematode resistant rootstocks have been developed which are named as Nemaguard and Shalil.

Diseases

(i) Bacterial Gummosis

They disease is common to almost all the stone fruits. Circular to elongated soaked gumming lesions develop on the bark or outer sap wood and fruits.

(ii) **Peach Leaf Curl**

Curling, puckering and distortion of young leaves occur. The infected portions develop pink or red bronze colour.

(iii) **Brown Rot and Blossom Blight**

Small, circular, brown spots appear on the fruit which are subsequently covered with ash coloured tufts. The brown rot fungus also affects the flower and causes wilting of the blossom. The disease extends to shoots causing wilting and cankering on the young branches.

(iv) **Frosty Mildew of Peach**

Small, white, powdery spots appear on the lower sides of leaves resulting in premature yellowing and defoliation.

(v) **Leaf Spot of Peach**

Small, angular, ash coloured spots appear on the underside of the leaf which results in premature defoliation.

(vi) **Powdery Mildew**

In addition to peach, it also affects apricot. White, mealy powder appears on the young leaves and current year's growth. Further growth of the infected buds, shoots and leaves is checked.

(vii) **White Root-rot**

The main symptom are weakened condition of foliage and twig growth; brown to very dark brown colouration of the infected roots; appearance of whilte fungus in the rainy season.

(viii) **Peach Rust**

Rusty pustules appear on the leaves.

All the above-mentioned insect pests and diseases are controlled by an integrated spray schedule which more or less is common for all the stone fruits like peach, plum almond apricot and cherry.

Integrated Spray Schedule for Stone Fruit (Peach, Plum Almond, Cherry and Apricot) orchard.

Note: Chemicals are for 200 litres of water

(i) **Dormant Spray (December-January)**

Carbendazim (100 g) + Bordeaux Mixture (5:5:50) or Copper oxychloride (600 g) + Hindustan Petroleum Tree Spray Oil (4 litres).

Single dormant spray of Carbendazim will protect the tree from fungal peach leaf curl infection. Oil is sprayed if scale is a problem.

During general pruning in winter infected twigs and cankered or dead/diseased wood are removed and burnt. Wounds are covered with fungicidal paint (*Chaubattia* or Copper oxychloride) or Bordeaux paste.

(ii) **Pre-bloom Pink or White Bud Stage (February-March)**

Carbendazim (100g) or Captafol (600g) or Copper oxychlorid (66g) + Diomethoate, 0.03% (200 ml Rogor 30 EC) or Methyl demeton, 0.25% (200 ml Metasytox 25 EC) or Monocrotophos, 0.04% (225 ml Nuvacron/Monocil 36 WSC).

Spray of these pesticides 7 to 10 days before flowering gives effective control of leaf curl caused by fungus and aphids. It also gives protection from leaf

spots, shot-holes and leaf eating insects.

For control of gummosis caused by flat headed stem borer, the main trunk and limbs are swabbed with Methyl parathion (40 ml Metacid 50 EC) in 10 l water). It is also effective against bark eating caterpillar.

(iii) Post-bloom Fruit-set Stage (March-April)

Spraying with Methyl demeton 0.25 per cent (200 ml Metasystox 25 EC) or Formothion, 38% (300 ml Anthio 25 EC) + Urea 1 kg.

(iv) Pre-harvest Stage (May)

Spraying to be done with Captan (600g) or Difolation (300g) + Fenintothion 0.05 per cent (200 ml Folithion/Sumithion/ Accothion 50 EC) or Monocrotophos 0.03% (200 ml Nuvacron or Monocil 36 WSC).

If fruit-fly is a serious problem especially in warm localities, the tree and nearby bushes are to be treated with bait spray (1 kg Jaggery + 200 ml Cythion 50 EC).

(v) Post-harvest Stage (July-August)

For the control of gummosis caused by flat headed stem borer, the main trunk and limbs are swabbed with Methyl paration.

Harvesting, Yield, Handling and Storage

Peach fruit is perishable and should be marketed quickly after harvesting. The best time of harvesting is when ground colour changes from green to pale yellow. On an average, a yield of about 35 kg per tree and 17,000-18,000 g per hectare may be obtained.

Fruits are packed in wooden or corrugated cardboard boxes of 5 kg and 10 kg capacity.

The firm and unripe peaches can be stored for 2-4 weeks at about 0^0 C and 85 per cent relative humidity.

QUESTIONS

1. Why is training and pruning in peach necessary? Explain the methods of training and pruning followed in peach cultivation.
2. Explain the following:
   i. Origin and distribution
   ii Flowering and fruiting
   iii. Propagation of peach
3. Write short notes on:
   i. Peach fruit-fly
   ii. *Shan-e-Punjab*
   iii. Peach rust

CHAPTER 20

Plum

Introduction

The plum (*Prunus spp)* is a temperate fruit of great commercial importance. It thrives well in hilly areas but under favourable climatic conditions can be grown in the plains also. Plum is very juicy, sweet and refreshing.

Plums are used fresh as table fruit and also for making jam.

Origin and Distribution

Plum is a native North America and Japan. The major plum producting countries are Yugoslavia and Germany. Also, the United States of America, former USSR countries, Austria, The United Kingdom, Spain, Turkey, Hungary, France, Japan, Italy, Poland, Mexico, Canada and Czechoslovakia produce sizeable quantities of plums.

In India about 40 per cent of the area under plum is in Kashmir. Besides, it is grown in Himachal Pradesh, Uttar Pradesh hills, Nilgiris and Eastern ranges of the Himalayas.

Botany

Plum belongs to family Rosaceae. It can be classified into three distrinct groups:
1. European plums -*Prunus domestica*
2. Japanese plums -*Prunus salicina*
3. American plums -*Prunus americana*

The plum trees are robust and have larger ovate and thin, irregular, serrated leaves. Flowers are solitary, white or cream in colour.

Area and Production

The total production of plums in the world is estimated to be 6 million tonnes. In India the annual production is approximately 40,000 tonnes.

Climate

Being a temperate fruit, cool winter climate is essential particularly during December-January to break the dormancy of buds. However, they are adapted to wide range of climatic conditions with well distributed rainfall. The plums can be grown from 1,000 to 1,600 m above sea level. Some subtropical plum, varieties having chilling requirement of only 250 to 300 hours are grown in the plains of North India. such varieties mainly belong to Japanese plums (*P. salicina)*

Soil

Plums require a well drained, deep fertile,

loamy soil with sufficient organic matter.

Varieties

(i) *Santa Rosa*

Fruits are large, dark reddish purple in colour; flesh is juicy and golden yellow; plants are regular and prolific bearers; self fruitful.

(ii) *Beauty*

Very early; medium size; delicious, sweet, deep red coloured fruits; clingstone; regular and prolific bearer; self fruitful.

iii. *Early Transparent Gage*

A regular and heavy cropper: fruits are small and roundish: colour is pale yellow with red dots.

(iv) *Grand Duke*

Fruits are large, dark purple, oval in shape; good for making jam.

(v) *Kelsey*

Fruits are heart shaped: greenish yellow in colour, the flesh is yellow, juicy, firm and of good quality.

(vi) *Meriposa*

Fruits are large, dark purple in colour having free stone. Flesh is also purple.

Propagation

The plants are propagated by T budding or tongue grafting on wild apricot and wild peach seedlings. Clonal rootstocks of *Brompton, St. Julian 'A', Myrobalan 'B'* and *Mariana* can be used. The budding is done during May-June and grafting in February-March.

In some varieties like Santa Rosa, softwood cuttings taken in December and treated with IBA 1,000 ppm root very well.

Planting

The planting distance varies with the varieties. Generally a spacing of 5x5 m is considered optimum.

The planting time, procedure and precautions are the same as in the case of apple.

In the intial 5-6 years of planting, suitable crops preferably legumionous for green manuring is suggested. In winters shallow cultivation should be done in order to suppress the growth of weeds.

Training and Pruning

The main object of training and pruning in plum trees is to build a strong framework whch can carry a heavy load of crop without breaking of branches and limbs. Different varieties of plum have different growing habits, and as such they are pruned differently. In general modified leader system is followed in whch the central leader is allowed to grow up to 2 m and then headed back. A lateral is allowed to develop as central leader. Four to six scaffold branches are maintained all around the main stem.

Plum tree bears fruits laterally on one-year-old wood and on spurs. To ensure regular and high productivity, pruning is designed to produce 25 to 50 cm growth in young trees and 25 cm growth in bearing trees. Moderate to heavy pruning is recommended to maintain proper fruiting and growth.

Manuring and Fertilisation

The plums require plenty of nitrogen and bulky organic manures. The quanity varies with the age of the plants. One year old plants require 10 kg Farmyard anure, 50 g N, 25g P_2O_5 and 60 g K_2O. The quantity of manures and fertilisers is increased gradually up to 10th year, After the 10th year, a full grown tree should receive 60 kg FYM, 500 g N, 250 g P_2O_5 and 600 g K_2O.

Organic matter in the form of FYM or compost is applied in December-January along with P_2O_5 and K_2O. Nitrogen is applied in two split doses, first in spring before flowering and second, one month later by broadcasting under the canopy of tree.

Irrigation

Irrigation should be done specialy during dry spells to maintain proper moisture in the soil.

Mid May to June is the peak period of water requirement for higher yield. Six irrigations at an interval of 8-12 days are recommended. Mulching during dry months with dry grass or hay 10 to 15 cm in thickness helps in conserving moistrue and reducing the frequency of irrigation and hence, economy in the use of available water.

Flowering and Fruiting

Flowering in plum takes place during March-April. Most of the plum varieties are self fruitful and are heavy bearing. For self unfruiting varieties like *Satsuma*, adequate pollinisers are needed for good fruiting. It takes 80 to 110 days for the fruits to mature. Spray of NAA or 2,4, 5-T at 50 ppm results in better fruiting. Application of calcium nitrate one per cent at pit hardening stage resulted in better firmness of fruits and increased shelf-life.

Insect Pests and Diseases and Their Control

For better returns control of pests and diseases is very important. In plum the pests and diseases mentioned should be taken care of.

Insects

(i) Peach Leaf Curl Aphid

Pach leaf curl aphild can be controlled by spraying Metasytox 0.03 per cent or Rogor 0.05 per cent at pre-bloom stage.

(ii) Blossom Thrips

Control measures are same as suggested for peach leaf curl aphid.

(iii) Plum Scale

Plum scale can be controlled by dormant spray treatment in January as suggested for San Jose scale.

(iv) Plum Moth

Spray of Carbaryl at 0.05 per cent, one month before harvest.

(v) Borers

Same as recommended for apple.

(vi) Defoliating Beetles

Same as recommended for apple.

(iv) Root Knot Nematode

Use nematode free planting stock.

Diseases

(i) Peach Leaf Curl

Single dormant spray of Blitoz at 0.2 per cent or Carbendazim to be given during first fortnight of January.

(ii) Brown Rot

Spraying with Difolatan at 0.2% or Captan at 0.15 per cent about three weeks before harvest.

(iii) Powdery Mildew

Spraying with wettable sulphur at 0.2 per cent or Carbendazim or Sulfex at 0 2 per cent before opening of blossom at petal fall and two weeks later.

Harvesting and Yield

Plum should be harvested when ε'' hard but has attained proper colour. Prematurely harvested plums do not ripen properly. Variety *Santa Rosa* takes about 104 days from flowering to harvest. A grown up plum tree may yield about 60 kg of fruits per year.

Handling and Storage

The fruits are graded according to size and quality and packed in 5 kg or 10 kg wooden or corrugated cartons. As the fruit is highly perishable, is should be marketed as quickly as possible.

QUESTIONS

1. Give the origin, destribution and clssification of the plum.
2. Discuss the methods of training and pruning followed in plum
3. Explain the following:
   i. Flowering and fruiting
   ii. Propagation
   iii. Harvesting.

CHAPTER 21

Apricot

Introduction

The apricot (*Prunus armeniaca*) is also called *Zardalu* in India. It is a good source of carbohydrates, minerals and vitamins. Apricot fruits are used as table fruit or for making jam. The kernels are used for the extratction of oil which is used for cooking of fool and the leaves serve as fodder for sheep and goat.

Origin and Distribution

The origin of apricot was earlier supposed to be from the Caucasus Monutains, and hence the name *Prunus armeniaca* but it is presently, believed to have originated from Western China.

Major apricot producing countries are the former USSR countries, the United States of America, Spain, France, Hungary, Turkey, Italy, Bulgaria, Australia, Greece, Syria, Iran, Israel and China.

In India, apricots are cultivated in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh hills and Nilgiri hills.

Botany

Apricot belongs to the family Rosaceae, sub-family Prunoideae and genus *Prunus*. The cultivated species is *Prunus armeniaca*.

The common apricot is a small tree, 6 to 9 metres in height, with reddish bark and glabrous twigs. Leaves are ovate to round ovate, sometimes sub-cordate, abruiptly short pointed, mostly obtusely serrate, glabrous above, pubescent veins beneath, petioles with conspicuous glands. Flowers are pinkish or nearly white, produced before the leaves. Fruits are velvety when young, peach-like in colour and shape. Flesh is yellowish orange, stone smooth and flattened.

Some varieties are characterised by having sweet kernel.

Area and Production

World production of apricot is 1.8 million tonnes per year. India produces approximately 20,000 tonnes per annum.

Climate

The areas best suited for growing apricot are those which have moderate summer temperatures. It thrives best in the mid-hills at elevations from 1,000 to 2,000 metres above sea level. It is very susceptible to frost due to early flowering

in February and March. Temperature limit for blossom lies near about -2°C and for fruit-setting is -0.5°C. However, white fleshed, sweet kerneled apricots require a colder climate for their successful cultivation and hence are grown in high hills.

Soil

Apricot needs deep, fertile and well drained loam soil.

Varieties

Mid hills

New Castle, Shipley Early

High hills

Kaisha, Nugget, Suffaida, Charmagaz, Shakarpara.

Dry temperature zone

Drying type varieties like *Charmagaz, Suffaida, Shakarpara* and *Kaisha.*

The important varieties of apricot are described below:

New Castle: Fruits are roundish or nearly spherical, medium sized, highly colourd, orange yellow; flesh juicy and sweet; regular in production, picked in early June.

Shipley Early: Fruit is medium sized, roundish, skin creamy-white with red flesh on the sunny side; flesh meshy, juicy and of average quality; ripens in the middle of May being earliest of all varieties.

Royal: Fruits have dull, yellowish skin with reddish tinge; fruit is large in size and roundish oval in shape; flesh is yellow, firm juicy with high flavour when fully ripe; ripens in mid June; stone-free to partly clinging; used as dessert or for canning.

Kaisha: Fruits are medium sized, round in shape; skin is yellow with red cheek; flesh orange yellow with good flavour; very prolific; ripens in the middle of June.

Propagation

Apricot varieties are usually grafted or budded on wild apricot seedlings. The wild apricot is named as *Zardalu.* Certain types of peach and plums can also be used as rootstock. Plum stock is useful for heavy soils. *Brompton,* a vigorous plum stock is preferred for large trees, while *St. Julian (East Malling)* plum stock is recommended of dwarf trees. *Myrobalan* plum, being resistant to nematodes is also a good rootstock for apricot.

The methods of propagation commonly used are either tongue grafting or 'T' budding.

Planting

Apric ot trees are to be planted at 6-8 metrespacing either way. The time of planting like apple and peach, is during winter months when the plants are dormant. The care of young plants is also similar to that of peach.

Training and Pruning

The apricots are trained on modified central leader system. In this case the central axis is allowed to grow and is headed back at 2 m height. A total of 4 to 6 scaffold branches are allowed to develop around the stem and a lateral is allowed to develop as central leader.

Pruning of Bearing Trees

Apricots are spur bearers and the pruning should be less severe than in peaches

but more severe than in apple. Such pruning is confined to the thinning out of branches that crowd or cross each other to ensure healthy development of the desirable branches through adequate aeration and exposure to sun.

The apricot spur is known to have a productive life of about three years. Hence, for the first three years no severe pruning is required. Pruning may be done to secure more spurs in place of those broken while harvesting. Afterwards, pruning, is to be so regulated as to ensure production of new spurs which replace the older non-productive spurs or those which get broken or are dead. In addition, diseased, broken and unwanted shoots are pruned.

Interculture

Like peach or any other temperate fruit, shallow intercultivations are required to keep the interspace between the trees free from weeds. The young orchards can be intercropped by suitable crops like peas, beans, cabbage, pulses or any other leguminous crop. Leguminous crops can also be used for green manuring.

The trees basins are also to be kept weed free and covered with mulch.

Manuring and Fertilisation

The nutrient requirements of apricot tree are generally similar to those of peach and hence a similar schedule is followed. The mature tree, requires 60 kg FYM, 500 g N, 250 g P_2O_5 and 600 g K_2O. However, unlike peach, out of total nitrogen to be applied, 80 per cent is applied to the soil in two split doses, and 20 per cent N is applied through foliar spray of 2.5 per cent urea is given to improve the fruit-set and yield. Apricot, is sensitive to boron deficiency which affects the flowers and fruits. Spraying of 0.1 per cent boric-acid before flowering to check the incidence of blossom blast or after petal fall is recommended to overcome boron deficiency.

Irrigation

Wherver possible irrigation should be given during the dry spell especially when fruit is developing. Irrigation at 10-15 days interval during this period results in larger sized fruits. When irrigation water is not available, conservation of moisture is very important. This is done by mulching as in case of peach. Even in irrigated areas mulching with dry grass or hay 10 to 15 cm in thickness helps in reducing the frequency of irrigaion and hence economy in the use of available water.

One or two irrigations may also be needed after mosoons are over to avoid excessive drying of roots. Failing this, there is premature leaf fall and the subsequent crop is adversely affected.

Flowering and Fruiting

Apricot flowers in February-March. Most of the apricot varieties are self-fruitful and set good crop in solid blocks of single variety. Apricot flowers are very sensitive to cold spells, hail and frost during flowering. Such inclement weather reduces fruit-set resulting in reduced fruit yield. However, if the weather is favourable, there is heavy fruit-set necessitating thinning in order to have good sized fruit of desired quality. This is done first by removing one fruit from each pair and then further thinning to get a space of about 12 cm for each

developing fruit.

Insect Pests and Diseases and Their Control

Apricots are relatively less attacked by pests and diseases. Some of the important insect pests and diseases of apricot are given below.

Insect Pests

(i) Blossom Thrips

This insect can be controlled by pre-bloom spray of Metasystox or Monocrotophos.

(ii) Borers

The control of stem, root and shoot borers is similar to that of apple and peach.

(iii) Defoliating Beetles

The control is similar to that of peach.

Diseases

(i) Powdery Mildew

Control measures are same as in peach or apple.

(ii) Stigma Blight

Light yellow to reddish coloured spots appear on leaves which susbsequently form shot holes. This occurs mainly in peach and apricot. Fruits develop dish brown measles on the outer surface. Control measures include spraying tree with Copper oxychloride (300g/100 l of water) before leaf fall and bud swell.

(iii) Collar Rot

Control is the same as for apple or peach.

Harvesting

Apricots must be picked by hand individually and carefully when ripe or a little earlier when still hard. As the fruit is highly perishable, the harvested fruits should be marketed at the earliest after harvest. The fruits are usually packed in wooden or cardboard boxes of 5 kg and 10 kg capacity.

Yield

We may obtain an average yield of about 40 kg per tree or 11,000-11,500 kg per hectare per years.

QUESTIONS

1. Apricot is a very important crop of the cold desert region". Justify the statement looking to its suitability in that area.
2. Explain the following.
   i. Climatic requirement
   ii. Pruning of bearing trees
   iii. Harvesting of apricot.
3. Write short notes on:
   i. Stigma blight
   ii. *Zardalu*
   iii. *Kaisha*

CHAPTER 22

Phalsa

Introduction

Phalsa (Grewia asiatica L.) is indigenous to India and is grown in many parts of the country. It is commercially cultivated in the states of Punjab, Haryana, Rajasthan, Uttar Pradesh and Madhya Pradesh, besides, it is also cultivated on a limited scale in the states of Maharashtra, Gujarat, Andhra Pradesh, Bihar and West Bengal. While the crop is popular, it is not grown on large scale anywhere, because the fruit does not keep well and has to be marketed locally. There seems to be good potential for *phalsa* cultivation near the cties.

Phalsa fruits are sub-acidic and a good source of vitamins A and C. They are a fair source of phosphorus, iron and calcium also. The fruits are excellent for making juice and squash and have a cooling effect. The shoots of the plant after pruning can be utilised for making baskets and also as supports for vegetable crops. *Phalsa* baskets are fairly strong and can be used for transporting fruits and vegetables. The bark of the shoots can be used to extract fibre which can be used for making ropes.

Climate and Soil

Phalsa is a very hardy crop capable of growing and fruiting in hot, dry environment and also thrives well in the humid tracts. The plants can tolerate temperatures as high as 44°C and also withstand freezing temperature for a short period. It can be grown on a wide range of soils including moderately alkaline soils. *Phalsa* can be grown successfully in fields where other crops cannot be grown gainfully.

It is not only well adapted to drought but can tolerate waterlogged conditions. But the plants become chlorotic and these is poor growth in such situations.

Varieties

The only member of the family Tiliaceae which yields edible fruits in the genus *Grewia, Grewia asiatica* L. known as *Phalsa* and is of commercial importance. There are no named varieties available in *Phalsa*. But two distinct types i.e., tall and dwarf are identified at Hisar. The dwarf one is known as *Chatri phalsa*.

Propagation

Seed propagation is common in *Phalsa* but cuttings can also be used with the aid of growth regulators. Seedlings are fairly true to type. Seeds keep their viability for about 6 months and they take 20-30 days fr germination. Seedlings of 3-4 months age can be planted in the main field.

For rooting of cuttings, the shoots have to be ringed 15 days before planting and treated with 2,500 ppm IBA. Hardwood cuttings treated with Ethrel 250 ppm for five minutes followed by 3,000 ppm IBA for two minutes, rooted up to 76 per cent. Air layering is also successful with a combined treatement of growth regulator IBA and NAA at 1,500 ppm each. Soft wood grafting on seedlings rootstocks is reported to give 100 per cent success. However, use of cuttings, air layering and grafting in *Phalsa* propagation is rare presently.

Planting

Usually, *Phalsa* is planted at 2.5-3.0 m apart both ways, during July-August or February-March. *Phasa* is well suited for close planting as the plants have to be pruned constantly to get the crop. It can be planted in a paried row system wherein two plants are planted at one place at a distance of 60 cm and the second pair of plants are planted at a distance of 3 metres from the first pair of plants.

Pruning

Phalsa fruits are borne in clusters in the axil of leaves only on the growing shoots. Pruuing encourages new growth and ensures regular and heavy fruiting. In the North, pruning is done during December-January where the plants are dormant and one crop is taken every year. However, in the South, two crops can be taken in a years since it takes only 4-5 months to complete flowering and fruiting from the time of pruning. The first pruning can be done during December and the second during June. The desirable height of pruning is 1/2 to 1.0 m from the ground level. This gives more number of new shoots and thereby higner yields compared to severe pruning, to ground level, as is practiced locally.

Manuring and Fertilisation

Phalsa responds well to manuring and fertiliser application, since the crop is borne on new growth and substantial quantity of nutrients are removed by way of pruning every years. Application of 100:40:25 kg NPK per hectare should be done to obtain high yields. The fertilisers have to be applied soon after pruning followed by light irrigation.

Irrigation

Phalsa is a drought hardy plant and does not normally require any irrigation for the crop survival. During fruiting period, lack of adequate soil moisture affects the fruit size and ultimately the yield. Hence, providing at least 3-4 irrigations at intervals of 15 to 20 days is ideal when the plants are in fruiting.

Improvement of Fruit Set, Size and Ripening

Applications of growth regulators and micronutients are found to improve fruit set and yield in *Phalsa*. Spraying NAA at 10 pm or 2,4,5-T at 5 ppm twice at an interval of seven day after 50 per cent fruit set helped in increasing fruit size.

Foliar spray of micronutients like zinc and iron in the form of $ZnSo_4$ and $FeSO_4$ at 0.4 per cent at prebloom stage and after berry set, improves fruit size and weight. For induction of uniform ripening and to facilitate easy harvest, applicaion of 1,000 pm Ethrel at fruit maturity results in maximum ripening within 5 days after application.

Insect Pests and Diseases and Their Control

Insects

Usually *phalsa* is free from serious pests and diseases but sometimes attacked by the following:

(i) Bark Eating Caterpillar (*Inderbela sp.*)

The caterpillar makes tunels in the main branches and trunk, and the affected plant die after sometime. This can be controlled by injecting kerosene oil or petrol in the holes and plugging them. Injecting 0.05 per cent emulsion of Monocrotophos or DVP in each hole followed by plugging with mud paste effectively controls the pest.

(ii) Brown Beetle (*Anamola sp.*)

The beetle feeds on foliage and is more severe during rainy season. It can be controlled lby spraying Nuvocron at 0.1 per cent.

(iii) Brown Spot *(Cercospora grewis)*

This disease causes premature leaf fall mainly in the rainy season. Tiny spots occur on both sides of affected leaves. It can be controlled by spraying Dithane Z-78 at a concentration of 0.3 per cent.

Harvesting and Marketing

Good crop is obtained from the third year after planting. The fruits start ripening four months after pruning. Harvesting has to be done selectively picking deep red or purple coloured fruits. The ripe fruits are highly perishable and have to be marketed as soon as possible or within 24 hours. The average yield from a mature plant is about 2 to 3 kg. One hectare of *Phalsa* yields 5 to 6.25 tonnes of fresh fruits which if disposed of every day would fetch 50 per cent more returns in addition to cost of cultivation within one year of planing.

QUESTIONS

1. Discuss the nutiritional and economical importance of *phalsa*.
2. Why is pruning necessary for *phalsa* cultivation? Explain the procedure in detail.
3. Explain the following:
   i. Improvement of fruit set, size and ripening *of phalsa*
   ii. Harvesting and marketing of *phalsa*.

CHAPTER 23

Jamun

Introduction

Jamun (Syzygium cumini Skeels) is an important indigenous minor friut of commercial value. It is medium to large shapely and handsome tree generally grown for its shade along roads and avenues and also as a wind-break. *Jamun* bears fruits for a long period, and 60 to 70 years old bearing trees are not uncommon.

The delicious fruits are a good source of iron and sugars. The fruits are deep purple in colour with a sub-acid spicy flavour. It can also be processed into beverages, jellies, jams and squash which make a very refreshing drink in summer. The fruit syrup is also useful in curring diarrhoea. The *Jamun* seeds are rich in protein, carbohydrates and calcium and can be used as a substitute concentrate in animal feeds.

The original home of *Jamun* is reported to be India or East Indies. It is also found growing in Thailand, the Philippines, Madagascar, West Indies, East and West Africa, Florida, California and Israel. In India, it grows in tropical and subtropical regions. Being very hardy, it is gaining importance in dryland orcharding.

Jamun (Syn : Kambul; Java Plum; Indian Blackberry; Black Plum) belongs to the family Myrataceae, and the genus *Eugenia* comprises of about 21,000 species. Some of the old world *Eugenia* spp. are placed in the genus *Syzygium*. The *Jamun* is *Syzygium cumini*. A wild species *S. fruticosum* with small and edible fruits is grown as a wind-break and also as an avenue tree.

Climate

Jamun can grow in tropical and subtropical climate. It grows in the lower ranges of the Himalayas up to 900 m and in the Kumaon hills upto 1,600 m. It needs a dry atmosphere during flowering and fruiting. Young plants are susceptible to drought and cold.

Soil

Jamun requires deep loam and well drained soils. Heavy or light sandy soils are not ideal.

Varieties

The most commonly known variety is the *Ram Jamun* which produces large oblong fruits of deep purple or bluish black colour. It has light pink or grayish pulp which is juicy and sweet. The seed is comparatively small in size. The fruit ripens in June-July.

Another variety producing small and round fruits of purple colour, is inferior to the oblong variety. It has large seeds and low juice content.

Propagation

Jamun is commonly propagated by seed. The seedling trees. however, show considerable variation in fruit size and quality. So it is desirable to propagate this fruit tree by vegetative methods.

The most common method of propagation is by seeds. Seedling trees are hardy and long lived but are not always true after extraction for hgh percentage of germination, because they loose viability quickly. Seeds are sown 3-5 cm deep with a spacing of 25 cm between rows and 15 cm between seeds in a well prepared nursery. The seeds start germination in 2 to 3 weeks and the seedling attains a height of 15-25 cm and is ready for transplanting in the next monsoon. *Jamun* seeds are polyembryonic to the extent of 25 to 50 per cent.

The important vegetative propagation methods are given below.

(i) Approach Grafting

Seedlings of *Jamun* are used as rootstock. Two year old seedlings are grafted during june-July. Six weeks are necessary for the union to occur.

(ii) Veneer Grafting

One year old seedlings can be used as rootstock. Scions should be selected from the spring flush and grafting done by July.

(iii) Budding

Budding is a common method of propagation in Indonesia. This method is better than approach grafting. One year old 10-12 mm thick rootstocks budded in July-August give better success. Bud wood should be taken from 1-2 year old vigorously growing shoots. Oatch or Lorkert method is followed. In Uttar Pradesh, 70 per cent success is obtained by patch budding in the month of March.

(iv) Air Layering

Over 60 per cent success in air layers has been obtained when treated with IBA 500 ppm.

Planting

Transplanting cna be done in July-August. They should be planted with a spacing of 10-12 m in pits of 1 m^3 dug in May-June and prefilled with top-soil and farmyard manure. When grown as wind-breaks they can be planted at a distance of 10 to 15 m.

Training and Pruing

In the early stage of plant growth. the tree is trained to form a clear trunk of one metre height with 3-4 well placed branches to form a good framework. In later years, the pruning consists of removal of dry twigs and improperly placed and criss-crossing branches.

Intercropping

Fruit crops like guava, *Kagzi* line and papaya, as fillers and field crops like *red-gram, mung*, etc. can be grown as inter crops.

Manuring and Fertilisation

During pre-bearing period, 20 g FYM per

year is applied which is gradually increased to 50 g at the bearing stage. In fertile soils, manuring leads to excessive vegetative growth at the cost of fruiting.

Irrigation

In the early stages, plants need 8-10 irrigations per year. Later, irrigation is not necessary. However, irrigation during flowering, fruit set and ripening will help in better fruit set and reduces fruit drop.

Flowering and Fruiting

The inflorscence is axillary. Flowering starts in the first week of March and continues up to the end of April. Flowers are hermaphrodite.

Jamun is cross-pollinated and pollination is done by honey bees.

Only 12 to 15 per cent of the fruits reach maturity. Flower drop can be reduced by 60 ppm GA spray at full bloom stage.

Pests and Diseases

(i) Leaf Eating Caterpillar (*Carea subtilis*)

The insect defoliates the trees. It can be controlled by Malathion spray.

(ii) Whitefly (*Dialeurodes eugenae*)

Whitefly can be controlled by maintaining sanitary condition in the orchard.

(iii) Leaf Spot and Fruit Rot (*Glomerella cingulata*)

Affected leaves and fruits show scattered spots. It can be controlled by spraying Dithane Z-78.

Harvesting

Seedling trees start bearing 8-10 years after planting and budded or granted plants after 6-7 years. Trees of 60 to 70 years of age are observed to be quite productive.

Fruits ripen in the month of June-July and harvesting is spread over a month. The fruits should be harvested when they attain deep purple colour. They are picked singly be hand. *Jamun* fruits are highly perishable and can be kept only for a day under ordinary conditions. On an average each tree yields about 80-100 kg of fruit.

QUESTIONS

1. Write a note on the nutritive and medicinal value of *Jamun*.
2. How do we propagate *jamun*? Describe the most commercial methods followed to proprgate it.
3. Write short notes on·
   (i) *Ram Jamun*
   (ii) Polyembryonic
   (iii) Flowering and fruiting

CHAPTER 24

Custard Apple

Introduction

The custard apple (*Annona spp.*) is also called *Annonas*. It belongs to the family Annonaceae. The genus *Annona* which has more than 70 species. Out of these, only five species of *Annona* produce edible fruits. They are (i) *Annona squamosal* L—*Sitaphal, Sharifa*, sugar apple, sweet sop and custard apple, (ii) *Annona cherimola—Lakshmanphal*, cherimoya. (iii) *A. reticulata—Ramphal*, bullock heart, (iv) *A. muricata* L—sour sop. (v) *A. diversiflia*—llma. In addition inter—specific hybrids (*A. squamosa* × *A. cherimola*) known as Atemoya are also important. Of these *Sitaphal* Cherimoya, and Atemoya have a potentia for becoming commercial crops in India

Origin and Distribution

Though custard apple appears to be indigenous to India because of its occurrence in sculptral designs in Ellora and Ajanta and its mention in Sanskrit literature, it is a native of tropical America and has been naturalised in several parts of India. Custard apple is either commercially cultivated or occurs in a wild state in Chile, Spain, Peru, Ecuador, South and North America, West Indies, Egypt, China, Central Africa, and Australia apart from the Indian subcontinent.

Custard apple occupies vast areas in Andhra Pradesh, Tamil Nadu, Maharashtra, Assam and Orissa, in a natrual form. However, commercial cultivation of the crop is yet to pick up and there is much scope to develop it on the plantation scale.

Climate and Soil

Custard apple in general is a tropical crop and preters a dry climate. While, Cherimoya prefers subtropical climate and produces more dry matter low root temperature than *Sitaphal* or inter specific hybrids, which prefer tropical climate. The tropical species when used as rootstocks under subtropical conditions can exert a dwarfing influence on scion, because of poor growth of rootstocks under low temperatures. *Annona* can withstand mild frost, but the fruits become hard and do not ripen in cold weather. During flowering season dry climate is preferred, but there is a high percentage of fruit set in humid weather.

Custard apple can be grown in any type of soils including sandy and marginal soils. They grow well in heavy

soils also, but cannot withstand waterlogged conditions.

Species and Varieties

1. Sitaphal (*A. Squamosa*)

(i) Local *Sitaphal*

The local *sitaphal* produces medium size fruits (average 225 g/fruit) containing many seeds, total soluble solids is 26° brix and acidity is 0.13 per cent On an average a tree may yield 50 fruits.

(ii) *Balanagar*

Balanagar yields large size fruits with an average weight of 260 g and with less seeds. Total soluble solids reaches up to 27° brix. The acidity is 0.24 per cent. A single tree may yield an average of 50-60 fruits.

(iii) *Mammoth*

This is another distinct variety of *Sitaphal*, native of West Indies. Its fruit is ovale and yields regualrly and is a dependent fruit bearer. The yield varies from 60 to 80 fruits, with an average fruit weight of 185 gram. The seeds are few and TSS is 23° brix. The acidity is quite low (0.19 per cent).

(iv) *Red Sitaphal (A. sangareddyii)*

This resembles the local *Sitaphal* in many aspects except colour of the fruit which is light reddish. The purplish tinge can be observed inside the fruit too and also in the leaf mid rib. The fruit is medium in size (230/fruit). Seeds are many. The TSS is 25° brix and acidity is 0.21 per cent. The tree bears 60-70 fruits per year.

2. *Bullocks's heart (Ramphal)/(A. reticulata)*

This species give big size fruits, on an average 390 g/fruit, and the fruits have comparatively less seed. The total soluble solid goes upto 28° brix and acidity is about 0.36 per cent. Reducing sugar per cent is 22.7 and non reducing sugar content 2.3 per cent. The yield ranges between 20 and 40 fruits per tree.

3. *Cherimoya (A. chdrimola)*

Cherimoya is not as sweet as *Sitaphal* and contains about 18° brix, with a distinct aroma and the pulp is mildly acidic. Average fruit weight is 180 g and the fruit contains 10-15 seeds. Cherimoya is fairly prolific in bearing with a yield of about 100 fruits per tree. It is more suited for cool and dry subtropical regions.

4. Custard apple hybrid (*A. squamosa* x *A. cherimola*)-*Atemoya*

This vanety is a cross between custard apple and cherimoya. It bears fruits of large size (average fruit weight 365 g), fewer seeds and of good quality (TSS 25° brix). The acidity is 0.28 per cent.

Propagation

Existing plantation of custard apple are of seedling origin, but it is preferred to follow asexual methods of propagation to perpetuate high yielding varieties. Sexual propagation can be used for raising the rootstocks as well as selection of improved geno types from seedling populations.

(i) Seed Propagation

Annona seeds take about one month for

germination, and the percentage of germination can be improved by treating the seeds with 350 to 500 ppm GA. Optimum temperatures for seed germination is 30-32° C and at lower temperatures (15-20° C) not only germination is delayed by 3-4 months but percentage also decreases.

(ii) Vegetative Propagation

Cuttings and air layering give very little percentage of success. Budding and grafting have given high percentage of success. Shield. Patch, 'T', modified Forkert and Chip budding can be used to propagate custard apple. Budding is to be taken up with the commencement of monsoon for best results.

Annona can be readily propagated by different grafting methods like Inarching, Whip, and Tongue, Veneer, Side and Cleft grafting.

Planting

Planting is done in the rainy season. Grafts are planted in the previously dug, exposed and filled in pits of the size of 60 × 60 × 60 cm at a spacing of 5×5 metre.

Manuring and Fertilisation

Custard apple is not given any manure generally, but under such conditions the tree declines prematurely and also yields less. It is therefore recommended to apply 250 g N, 125 g of P_2O_5 and 125 g of K_2O per plant with the commencement of monsoon. In addition application of 10 kg FYM per plant will be beneficial to increase the yield.

Irrigation

Occasional irrigation helps to improve fruit set and early bearing. Two crops are taken in irrigated orchards in Pune District.

Flowering, Pollination and Fruit Set

Flowering in custard apple occurs during the summer months and is closely associated with vegetative growth flushes. Flowers produced on basal noes are more fruitful than those close to apices. The flowering season extends from spring to the end of rainy season and only about 2 per cent of the flowers set and bear fruits. Pollination is a major problem in this crop.

The annona flower is hermaphroditic and exhibits protogyny. The protogynous nature prevents self pollination and fruit set. Compound and sticky nature of pollen grains make wind pollination difficult. Insect pollinators are rare. High temperatures and soil moisture stress also reduce the friut set.

Hand pollination has always givn higher percentage of fruit set by more than 40 per cent. Cultural methods or techniques which may increase humidity in the field, including the use of wind-breaks, planting trees at high densities, overhead, or under tree misting, irrigation scheduling during flowering, helps to increase the fruit set.

Crop Regulaion

Phenological observations revealed that Annona plants start shedding the leaves from December and initiate new growth in March-April. If new growth is induced during January by early defoliation with potassium iodide 0.5 per cent sprayed twice at one week interval or by manual defoliation, it significantly increases yields over control plants among the varieties.

Pests, Diseases and Disorders

Custard apple is a hardy crop and comparatively less prone to pest and disease attack. However, some disease are given below.

(i) Mealy bug

Mealy bugs attack fruits and make them unmarketable. Spraying Monocrotophos at 1.25 ml per litre of water, at regular intervals will control the mealy bugs. Banding of tree trunk with 20 cm wide alkathene/polythene (400 gauge) and application of grease to lower edge of the band prevent mealy bugs climbing up the tree.

(ii) Anthracnose (*Glomeralla cingulata)*

Anthrancnose causes leaf spot as well as fruit rot. Spraying Bavistin at 0.05 per cent or Dithane M-45 at 0.2 per cent or Dithane Z-78 at 0.2 per cent is effective against the disease.

(iii) Fruit Mummification (Stone Fruits)

After fruit set, some fruits turn brown of black after drying and become hard. Such fruits do not drop, but continue to stay on the tree. These are known as stone fruits. It is more due to compelition between the developing fruits, malnutrition, and lack of moisture. Stone fruit formation is found to be less when new growth is induced early in the season and the cropping period is spread over.

Harvesting, Handling and Marketing

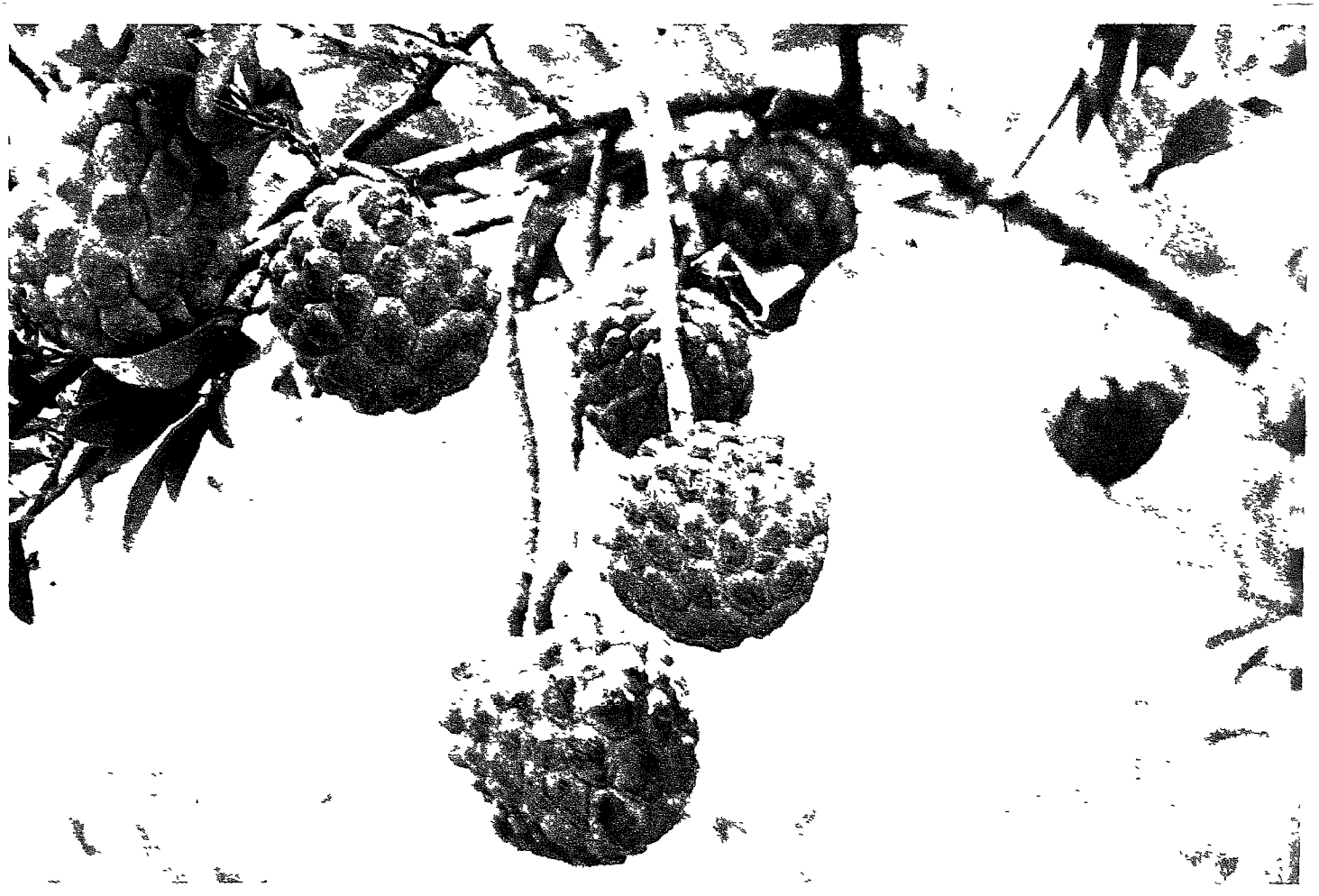
The fruits are harvested while they are still firm, after the skin between the segments has turned from green to cream yellow. If the fruit is left on the tree, the fruits spilt open and decay. Prematurely harvested fruit are of poor quality and some times do not ripen at all.

The Annona fruits ripen within three days after harvest. This is the main drawback in transporting the fruits to long distance markets. By dipping the unrips fruits in 8 per cent wax emulsion containing 200 ppm 2.4-D, ripening can be delayed for 7 days. The fruits do not stand cold storage.

Custard apples are harvested in October, when just mature and allowed to remain in a cool place. Firm mature fruits ripen in two days after harvest. These are immediately loaded in trucks and transported by train to distant markets. Fruits are graded by retailers into A grade fruits roughly 400 g, B grade 250 g and C grade having less than 250 g weight.

QUESTIONS

1. Write a note on the flowering, fruiting and crop regulation in *Annona.*
2. Write short notes on·
   i *Mammoth*
   ii. Atemoya
   iii. Extension of shelf-life



Beanng of Custard Apple

Bearing of Jackfruit

CHAPTER 25

Jackfruit

Introduction

The jackfruit (*Artocarpus integrifolia*) belonging to Moraceae family is a native of India, and is believed to have originated in the Western Ghats. It is now cultivated in several tropical regions such as Sri Lanka, Malaysia, Burma, Indonesia, Jamaica, Brazil, Bangladesh, East Africa and West Indies.

Jackfruit is popularly known as poor man's food, but is liked by everybody. Apart from being used as a table fruit, its pulp can be used in the preparation of jam, jelly, candy and in canning. The salted pulp is largely dehydrated and used as chips. The young fruits are used as vegetable, and seeds in culinary preparations. The rind of the fruit is an excellent cattle feed. The pulp which forms about 30 per cent of the bulk of the fruit, contains 63.1 per cent water, 0.6 per cent protein, 0.6 per cent fat, 1.8 per cent fibre, 23.4 per cent carbohydrate and 0.5 per cent ash.

The total area under jackfruit in India is estaimated to b e 26,000 hectares. Assam has the largest area of 8,000 hectares followed by Bihar (4,000 ha) and the remaining area of 2,000 hectares is in Andhra Pradesh, Karnataka and Tamil Nadu.

Climate

Jack fruit is a tropical crop and comes up well under humid and warm climate of hill slopes. It also does well in arid warmer plains of South India. If adequate soil moisture is available. It grows well in places having an elevation upto 1,500 m, but trees grown above 1,200 m MSL produce fruit of inferior quality. Jackfruit is sensitive to frost and drought.

Soil

Jackfruit grows well on a wide range of soils provided they are well drained. However, deep rich alluvial soils, loamy and laterite soils are quite ideal for jackfruit. Fluctuating water table is not desirable. Rich deep soild or medium or open texture are best.

Varieties

As Jack plants are still commercially propagated by seeds, there exists a lot of variation among the trees in the fruit characters such as shape, size and quality. Though no distinct types are recognised in jack, the cultivated types are broadly classified into two groups, those producing fruits with firm flesh

and those bearing fruits with soft flesh. The former produces a dull thud when sounded, while the latter yields to the pressure of thumb, when ripe. This is considered less delicious than the former. Several sub-groups have been recognised in these, depending upon the taste, shape and size of fruits or edible parts, odour of flesh, nature of shape and density of prickles on fruit rind. A third type called *Rudrakshi*, grows in South India. It maintains its characters even under seed propagaion. It is a small fruited type with smooth and less spiny rind than the common jackfruit.

Singapore or *Ceylon jack* was introduced into Tamil Nadu in 1947. This is remarkable for its early bearing in 2½ to 3 years. The fruits are medium in size, weighing about 7-10 kg. The flesh is sweet and crisp. The carpels are compact, yellow and firm and the aroma strong. This variety bears fruits from June to December. The fruits contains around 80 seeds.

Propagation

Seed Propagation

The common method of propagation in jackfruit is by seed. The seedlings are usually raised *in situ* during the rainy season, as the seedlings do not generally transplant well due to their delicate, long tap root. However, the pot grown plants can be planted during the rainy season quite successfully. Seeds weighing less than 3 grams are not desirable for seedlings. Germination will take place in three to eight wekks. The viability of jack seeds is short. The seeds are best sown immediately after extraction from the ripe fruit.

For rootstock, seedlings are raised in pots or first raised in seedbeds and then potted within about six months.

Approach Grafting

Six to twelve months old potted sedlings can be used as rootstock for grafting by adopting approach method. Softwood grafting has also found to be fairly successful.

The other methods of propagation are patch budding and air-layering. These techniques are yet to be standardrised for commercial propagaion for different situations.

Planting and After Care

Pits of 1 m^3 are dug at 9-12m apart, one or two months before planting and allowed to be exposed to the weather. If the soil is poor the pits are dug about 6 months in advance. They are filled with 20-30 kg well decomposed farmyard manure. Grafts are removed from the containers and planted carefully, so as not to disturb the ball of earth surrounding the roots. Planting is done during June-September in Southwest monsoon areas and extending up to December in other areas. A cool cloudy or humid evening is preferred for planting.

Training and Pruning

Normally no such operations are practiced by the growers, except that the lower branches of the main trunk are removed for providing shape to the trees.

Manuring and Fertilisation

It is recommended that an adult tree of

more than 7 years old, should be supplied with 50 kg of Farmyard anure, 600 g N, 300 g P_2O_5 amd 240 g K_2O per years. The fertilisers should be applied in two equal split doses during May-June and September-October. The fertilisers and manures should be uniformaly broadcast in the basin and mixed well with the soil.

Irrigation

Protective irrigation is necessary during summer and drought period, as jack is sensitive to drought. During such periods irrigation at intervals of 15 days increases the production to a considerable extent.

Flowering and Fruiting

The jack plant bears both male and female flowers. In the early part of flowering season, only male spikes appear and female flowers follow. The male phase persists for a fairly long period, while flowers of both sexes appear in one or more seasons. The female flowers mostly appear during February and March.

Fruit development takes about 125-140 days from spike emergence to maturity.

Pests and Diseases

The insect pests of jackrfruit are the shoot borer, caterpillar, mealy bug and scale. The shoot borer caterpillar bores into the tender shoots and buds and its spread can be prevented by clipping off and destroying the infected shoots. The mealy bug sucks sap from shoots and discolours the affected parts. The scale insect covers the leaves and twigs in swarms and sucks the sap. They can be controlled by spraying by some contact insecticide.

Among the diseases, pink disease, stem rot and fruit rot are found to affect jackfruit. They are not very important maladies and pruning the affected parts and protecting cut ends with one per cent Bordeaux paste is an effective control measure.

Harvesting

Seedling jack trees come to bearing within 6-8 years in warmer part of the country, but in North India it may take 10-16 years. *Singapore jack* comes to bearing in about 18 months. On an average a grown up plantation with 90 trees per hectare, may yield 9,000 to 10,000 kg fruits.

QUESTIONS

1. Why is jackfruit called a poor man's food? Justify the statement by giving suitable examples.
2. Which are the commercial methods of propagation followed in jack ? Explain the softwood method of grafting.
3. Write short notes on:
   i. *Singapore Jack.*
   ii. Jackfruit products.
   iii. Flowering and fruiting in jack.